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An Engineering Potpourri.

Attention is called to the proposed municipal engineering board described in a letter published elsewhere in this issue. The fantastic originality of the suggestion is equalled only by its bright promise of endless confusion. Evidently the engineering work in the city referred to is already so foot-loose and free from direction by a central authority that its further reduction to a state of impotence is not a difficult matter. The situation stated by the writer of the letter has evidently arisen from the exigencies of practical politics. In the multitude of official boards there is multiplication of jobs for all the cohorts of great and small leaders, and consequently in a city where politics is a thrifty business it is customary to see each public works department more or less independent, its affairs being directed by a distinct board which appoints its employees and is responsible only to the mayor. It is usually a wretchedly inefficient system, so far as economical and effective technical management of the different public works is concerned. The various boards fight between themselves for patronage and appropriations, and instead of helping each other as occasion arises, generally do their best to prevent progress. It sometimes happens that for financial or other reasons it becomes necessary for a city to place a certain kind of work in charge of some special board. If this is not done the work cannot be carried out, and a board organized under such circumstances has a real reason for existence. Every condition in ordinary municipal affairs points, however, to the importance of placing all engineering work under the charge of a single city engineer, as has been done for years with marked success in Boston, where the city engineer, as the technical adviser on all engineering matters, directs the work of all the department engineers and harmonizes their differences. His most important function, however, lies in acting as a buffer between the heads of the various engineering departments and the city legislative and administrative officers. The heads of departments are thus free from all annoyance, and the mayor, councilmen and others become accustomed to applying to a single man for the engineering information they require. It is a great deal better in any organization for the work of one general kind to be under a single head, who alone is authorized to say anything about it. This has been demonstrated repeatedly in business affairs, in the management of large railway and manufacturing companies, and in a number of important cities, and consequently only the demands of politics can account for such an organization as is stated to exist in the city mentioned by the writer of the letter.

There are few engineers who have the breadth of view qualifying them to direct the technical affairs of a large city. The average engineering specialist is rarely so qualified, for by training and inclination he is accustomed to regard certain branches in which he is particularly interested as of greater importance than they probably are and is equally inclined to underrate the importance of other branches. Moreover, it is generally the case that a specialist has been so thoroughly concerned with technical matters that he has neglected the business side of engineering. He is an excellent man to give advice regarding details of his specialty, but this is no reason for putting him in a position to criticize the works of other engineers engaged in different lines. In such a municipal organization as that mentioned in the letter, there is bound to be more or less departmental jealousy, and this feeling of dissatisfaction between the politicians directing the different boards will be reflected by their engineering assistants. On account of this jealousy, it is not at all unlikely that excellent engineering suggestions by the technical head of some department would be voted down by the majority of the proposed board of engineers, owing to mere spite. Theoretically, this should not occur, of course, but those who are familiar with the feeling that sometimes exists between different departments of large organizations, public and private, will recognize in the proposed plan an element of danger of the sort indicated.

The writer of the letter suggests that the engineers who form such a board and undertake to criticize work of their associates, of which they know little or nothing, are guilty of unprofessional conduct. This raises a point concerning which there will be marked differences of opinion. If such an engineering board could be organized and its members were to work together harmoniously, criticisms from ignorant or from semi-ignorant members regarding certain projects could not be looked upon as unprofessional but rather as inquiries for purposes of information alone. It hardly seems probable that any engineer would undertake of his own volition to vote against plans prepared by somebody who knows more about the subject than he does. But if jealousy arises, either personal or departmental, it is evident that all hope of efficient progress in any engineering branch will be completely lost. The contrast, therefore, between a properly organized engineering department with a city engineer at the head of the whole force and such a board of probably discordant members as is suggested in the letter, is strongly marked. Even assuming that each member of that board is an expert, it is probable that sooner or later he will feel the necessity of consulting with other specialists concerning some parts of his work. The suggestion that he should refer such matters to the people associated with him on the board, who are less well informed about them than he is, instead of to competent consulting engineers, is a ridiculous attempt to save money in trifles by risking enormous losses in large works.

Comparing Estimates with Construction Costs.

Few duties are more instructive in engineering practice than the comparison of estimates with the actual construction expenses relentlessly added by each day's progress from the beginning to the completion of the work in hand. The task is sure to be a pleasant one if the totals fall below the anticipated amounts, but in so many instances changed conditions or inaccurate forecasts modify the results expected or secured, that an engineer would be more than human if he did not feel the temptation to postpone the rigid comparison of early figures with late experience. In actual work it is almost always necessary to explain increases in grand totals to the financial powers back of the enterprise, but this is not the point at issue. The question which ought to be faced fairly and squarely is, how the results in detail check with the detailed estimates, and what are the causes of discrepancies.

If field notes are kept with sufficient care in explanation of unexpected changes in working conditions the problem ought to be a simple one. Presumably the original estimates and the contract prices will be properly filed at headquarters. When a job diary is posted from day to day with records of all important decisions of the supervisory engineers, agreements modified by consultation with contractors, delays in shipments, unforeseen obstacles in excavation and the like, the comparison of estimates and costs becomes an easy task, as far as explaining discrepancies is concerned. Errors of judgment are liable to occur in the most carefully prepared estimates, and the detection of these by stripping off all other uncertainties in comparison is the most valuable aid toward more accurate judgments in future work. It is decidedly worth while to know the unit costs of every large enterprise and most small construction jobs, even at the expense of a certain amount of clerical work, which at times proves irksome. It is not enough to apprehend the probable limits of a prospective cost range. Excavation, stripping of land, pole erection, blasting, fills and many other constructional activities all vary in unit costs according to conditions, and it is unquestionably valuable to be able to estimate such work with reasonable accuracy as checked by previous jobs.

If it is important for the engineer to verify his estimates with the actual results in cost details, it is equally essential for the client to appreciate that perfectly legitimate reasons may occur to change the original figures without in the least impairing the reputation of the engineer himself. When a client does not possess the mental breadth to realize the effect of conditions which could not have been foreseen, nothing is to be gained by volunteering explanations of why detailed items varied so widely in the actual costs, while the totals were close to those secured in the work. It is a personal matter for the engineer to determine, of course, how far it may be wise to offer explanations of this kind. Times are when they are asked for and appreciated when presented, but whether they are called for or not, every far-sighted engineer will check up the figures in the privacy of his office and will realize the immense importance of full memoranda as the job progresses.

The Improvements in the St. Mary's River.

The improvement of the West Neebish channel of the St. Mary's River, which is described at length in this and the preceding issue of The Engineering Record, affects a greater total tonnnage of shipping than any other similar work that has been undertaken in recent years by the general government. The traffic between Lake Superior and the other Great Lakes has increased at a truly remarkable rate in recent years, the net total of this traffic being nearly 52,000,000 tons in 1906, as compared with a net aggregate of approximately 19,000,000 tons in 1897. This rate of increase has been particularly great since the opening of the iron mines in the Messabe Range at the head of Lake Superior, although the traffic in coal, general merchandise, grain and grain products is proportionately as much heavier each year, due to the rapid development of the vast agricultural region tributary to Lake Superior. Furthermore, it may certainly be expected that the present rate of increase will be maintained, and probably given considerable acceleration during the next few years as the scope of various enterprises at the head of the lakes is broadened and as new industries now under construction in that locality are placed in operation.

The narrow tortuous course of the St. Mary's River, through which this great volume of traffic is required to pass in leaving or in entering Lake Superior, and the rapids in that river, have necessitated some exceedingly broad and expensive improvements. These have been carried on as rapidly as practicable, but, in general, have never kept pace with the increase in traffic sufficiently to permit vessels of the most desirable sizes to be used. The work that has been done at the rapids consists of a lock on the Canadian side and two locks on the American side, together with approaches to these locks. The latter passed 22,155 vessels in the season of 1906, and during June of this year 3,134 vessels were locked through them. While they are capable at present of handling this great traffic, at the existing rate of increase their capacity will soon be entirely inadequate. Plans for a third lock on the American side have been made, and the construction of this lock will be started within a year, but it can scarcely be finished before the traffic becomes greater than can be passed satisfactorily through the existing locks.

The work that has been done in the past in improving the channels of the St. Mary's River below the locks is briefly outlined, and the work now under way on those channels is taken up in detail, in the description to which reference has been made. From this description it is evident that the opening of the West Neebish channel will practically complete such work in the river below the locks until the depth of water in various other channels and harbors of the Great Lakes is increased. Even at that time the improvements which will then be required in the St. Mary's River can readily be carried on without interfering with traffic. The most desirable feature of this new channel on the west side of Neebish Island, however, is that after it is in use a practically double sailing course will be available from the locks at the head of the river to the mouth of the latter in Lake Huron. That is to say, where two channels do not exist the single channel is either naturally wide enough or has been widened and deepened so the upbound and the downbound traffic may be separated entirely. The downbound traffic going with the swift current of fthe river will then be allowed to take the right-hand course, including the straighter route offered by the West Neebish channel, while the upbound traffic will use the more crooked route around the east side of Neebish Island. The value to the heavy traffic in the river of the double sailing course thus made possible by the completion of the West Neebish channel can scarcely be overestimated, and the opening of the latter will certainly be followed by a greatly increased traffic tonnage through St. Mary's River, due as much to the possibility of operating the existing vessels to greater seasonal capacities as to the addition of new vessels to service.

The Superstructure of the Quebec Bridge.

Unusual interest attaches to the articles now appearing in The Engineering Record describing fully the principal details of the Quebec 1,800 ft. cantilever. A detailed account of the structural work of a large steel bridge, or other similar work, is not at the present time, generally speaking, a matter to which it is worth while to call special attention, but the Quebec cantilever is the longest span steel bridge of any type yet constructed, and the arrangements of its details are necessarily unusual in order to meet the extraordinary stress conditions existing in such a great structure. It is sufficiently remarkable to have the main column between the anchor and cantilever arms 315 ft. long, but when it is borne in mind that such a member may have to carry a total load of 10,000,000 lb. or more, chiefly conveyed to it by pins at its upper end, it is easy to realize that provision must be made for extraordinary conditions.

Before giving attention particularly to the main details of this structure, it is worth while to consider some of the principle features of its design. It is now well established that it is in general economical to make the length of the suspended span about one half of the main cantilever opening. In long spans, however, conditions resulting from the erection of a long cantilever arm may render it judicious to decrease the length of the suspended span, and in the present instance it was made three-eighths instead of one-half of the 1,800 ft. opening. It is probable that there would be economy of material with the greater length, but the difficulties of design and manufacture in making provision for the correspondingly increased erection stresses might easily balance or overbalance any small saving of material.

It is interesting to observe that the width of the structure between centers of trusses, 67 ft., is practically one twenty-seventh of the main cantilever span. This width of structure insures a lateral stiffness essentially equivalent to that of a simply supported truss span of the same length and loading, whose transverse width between centers of trusses is one-eighthteenth of the span length. This measure of lateral stability for a cantilever span was first established in connection with the design of the Red Rock cantilever, a structure also built by the Phœnix Bridge Co.

The system of web bracing for this great cantilever structure, 315 ft. deep over the main piers, is a single system with subdivided main panels making the subdivided panel length 56.25 ft. The plan of subdivision makes the secondary members compression and is similar to that used in many of the longer spans designed and built by the Phœnix Bridge Co. It secures a most effective web system in which no ambiguity or statical indetermination exists. Only one serious question arises with this arrangement, and that is, why the entire shear of the cantilever and anchor arms is carried to the top of the great center post, instead of transmitting it down to the bottom of the same post by an inclined compression member meeting the top chord two panel lengths from the top of the center post. The comparatively small depth of truss at the extremities of the anchor and cantilever arms gives an economical angle of inclination to the inclined web members of those portions of the trusses, but the angle becomes far less economical as the main center post is approached.

The massive character of the individual members and of their details can scarcely be realized, even with the comprehensive description given in The Engineering Record, except by those familiar with the corresponding members and details of some of the largest ordinary spans yet constructed. It is obvious that a suitable arrangement of the details at the intersection points of the chords and web members, has been reached only after the most careful consideration of all the ends to be obtained in the design. Central intersections in such a great structure are absolutely essential for the elimination of objectionable secondary stresses, and they could only be secured by a massiveness of details which is unprecedented in bridge construction. The system used can be properly called pin-connected and yet so much extraordinarily massive riveted work is found that an advocate of riveted joints could claim that the trusses are built as much on the riveted type as pin-connected, if not more so. As a matter of fact, the plans show the trusses to be an admirable developement of both pin and riveted work to meet the exigencies of this particular structure. They further conclusively demonstrate that the single web system may be successfully applied in a highly satisfactory manner to the longest span of truss work yet contemplated.

The Quebec Bridge, therefore, is a most interesting exhibition of modern structural design of the most advanced type, in its application to a railway bridge structure of a span so great that it was a question whether the stiffened suspension system should not be employed. The degree of excellence to which shop work of this class has been developed is effectively shown by the fact that these great bridge members were never assembled after fabrication in the shop until they were placed in the actual structure with complete accuracy. This is in marked contrast to the system of construction of the Forth Bridge, for which shops were actually equipped and put in commission at the bridge site in order to accomplish the fabrication, as it were, of each member in its actual place in the completed structure.

Notes and Comments.

The Hell Gate Bridge Plans for the Pennsylvania R. R. structure connecting Long Island and the Borough of the Bronx have been rejected by the Municipal Art Commission of New York. . This structure as planned was illustrated in The Engineering Record of June 1, and in a later issue it was stated that the Art Commission might request a modification of the architectural treatment. In its report the Commission states that it is quite ready to accept the judgment of the designing engineer on all engineering or structural questions, but the attempt to give decoration to the towers and to the bases of the towers is considered unsatisfactory from an artistic point of view. The report reads: "Your committee cannot approve these decorative features as they would have been ready to approve a strictly utilitarian construction, or, better still, a scheme of ornamentation which would seem to them artistic and appropriate. They, therefore, recommend disapproval of the plans without prejudice to their re-submission with a different treatment of the towers and their bases." In this connection it might be added that the "Builder," the leading British architectural journal, has also found fault with the architectural treatment of the structure.

An Electrolysis Controversy of considerable interest recently took place before a committee of the British House of Commons, which was listening to arguments for and against a bill introduced in favor of the North Metropolitan Electric Supply Co. The Metropolitan Water Board insisted that this bill should in no way exempt the company from responsibility for causing injury to underground conduits and other structures by electrolysis. The electric company produced experts who testified that there was absolutely no danger of electrolysis from works such as the company proposed to construct. The committee finally decided that, this being the case, there was no reason why the Metropolitan Water Board should not be protected in the manner it wished and accordingly inserted the clause desired. It is understood that, in spite of the electric company's assertion that it would cause no harm, the presence of this clause is a source of considerable annoyance. It seems unfortunate that British electrical corporations continue to fight attempts to get a better knowledge of electrolysis and the methods of providing a protection against it. In Germany the contrary is the case. There the Association of Gas and Water Engineers, which has been carrying on an investigation of electrolysis for many years, has been joined by the Association of Industrial Electrical Engineers and the Association of Tram and Light Railway Proprietors, in a joint committee to carry on the researches begun by the society first named. There is no attempt made in Germany to ridicule the effects of stray electric currents, but, on the contrary, the companies responsible for these wandering currents acknowledge their obligations and are doing their best to remedy the troubles. Such a course has been followed in a number of American cities, but up to the present time it has not found favor in Great Britain.

The Smokeless Combustion Experiments with Illinois coal which Prof. L. P. Breckenridge is conducting at the Engineering Experiment Station of the University of Illinois have attracted so much attention that the following notes concerning them will probably be of interest to many readers. The tests were begun with a Heine water-tube boiler of 210-h.p. having a Green chain grate stoker and induced draft in the furnace. The lower tubes of the boiler have been covered for two-thirds of their length with a special tile, making a roof in the furnace. Over a hundred tests have been made with soft coal, each of 8 to 10 hr. duration. With this setting no smoke has been caused during the operation of the boiler after the fires were once well started. A series of tests is now in progress with two types of heating boilers, using anthracite and bituminous coal, coke and briquettes. In all tests the technologic branch of the United States Geological Survey is co-operating. Prof. Breckenridge is of the impression that the smoke nuisance will be cured mainly by using mechanical stokers suited to the local coals, but the stoker must be combined with the proper furnace details to fit the coal used. Uniformity in the size of coal will be of material help. Where hand firing is adopted, careful firing, which is unusual, will cut down the smoke at least one-half. Details of the experiments and a complete description of several boiler settings which have operated without smoke for more than two years will be printed in a bulletin of the Engineering Experiment Station to appear arly this Fall.

Public Improvements in the Boston Metropolitan District are to be investigated by a commission consisting of three members appointed by the governor and two by the mayor, these men to be "skilled in finance, commerce, industry, transportation, real estate matters, architecture, engineering, civic administration and law," acccording to the law authorizing the appointment of the commission. The commission is authorized to investigate the advisability of any works in the district which, in its opinion, will tend to the convenience of the people, the development of local business, the beautifying of the district, or its improvement as a place of residence. It may also consider the establishment of intercommunicating highways between the cities and towns of the district, the control of traffic, the location of docks and terminals and other matters of this nature. The members of the commission, among whom Mr. Desmond Fitzgerald is included, serve without pay, but the commission may spend any sum up to $25,000 for clerical and other services. It will be noticed that the commission is essentially one of investigation, its powers in this direction being limitless, whereas it has no authority to execute anything. The appointment of the commission is particularly interesting in view of the somewhat similar action recently taken by the Local Government Board of Great Britain, and the appointment of a committee by the Royal Institute of British Architects to report on the æsthetic development of suburban tracts. It is becoming evident in all large cities that the time has been reached when a careful planning of the development of all outlying districts is important, not only from an engineering point of view, but also for the best commercial and artistic growth of the suburbs. This is a matter to which Mr. Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of New York City, has several times called attention in his official reports.

Injuries to Workmen engaged in rock excavation by the explosion of charges which have not been fired properly, occur so often that it is rather surprising contractors do not instruct their foremen to use the utmost care to prevent such accidents. The law governing these occurrences in most States was stated lately by the Minnesota Supreme Court in the case of Carlson v. James Forrestal Co., 112 N. W. Rep., 626. In this case the general foreman in charge of the work of excavation for the foundations of a building directed a blasting crew to go to another part of the foundation. He directed a certain workman, the plaintiff in the case, to clear the ice and snow out of a hole which had been drilled in the rock by other men, and this workman was injured by the explosion of a charge of dynamite left there unexploded when a group of holes had been fired electrically. In this case the company itself was not considered negligent in its manner of conducting the blasting, or in allowing the work to get into the condition which existed. Nevertheless, as a matter of law, the general foreman was a vice-principal, charged with an absolute duty to exercise proper care to provide a reasonably safe place for the men to work. The jury found that the foreman did not exercise such care in making a reasonable examination to ascertain if all of the charges had been exploded, and the accident was the proximate result of this negligence. Under such circumstances, the court rules, the defendant was responsible for the injury to the workmen, and it affirmed the verdict of $8,000 which he received in the trial court. This is practically the decision rendered in so many States that it may be accepted as practically universal throughout the country, and indicates that some general rules might very properly be drawn up for the guidance of foremen in charge of blasting operations and cleaning up after explosions.

The Drainage Works of New Orleans from time to time arouse more or less criticism from residents of that city, which seems to be based on the supposition that a drainage system can accomplish the impossible. Few cities are situated like New Orleans. The surface water which has to be handled there accumulates during and after heavy rainfalls in very large amounts, unless means exist for conveying it away rapidly. The drainage system has been constructed for the latter purpose, and where it operates under the conditions which were assumed to govern the work when the plans were prepared, it gives complete satisfaction. It goes without saying, however, that if the inlets to the drainage canals are allowed to become clogged with trash and refuse, the water which accumulates in the gutters cannot enter the inlets at the proper rate, and consequently must flow over the surface of the street until some better escape for it is found. This occurs from time to time in the city and gives rise to complaints that the drainage works are inadequate for their purpose. The contrary is really the case, for the trouble is due to failure to keep the streets and gutters clean. This is no fault of the Street Cleaning Department, for it has less than $200,000 to spend annually for the purpose, which is less than a quarter of the sum really needed for the removal of dirt and rubbish in a fairly satisfactory manner, particularly in view of the fact that in some parts of New Orleans it has long been customary to throw refuse directly into the streets. Complaint has occasionally been made, also, that the drainage works were not of the highest type, and that some of the open canals should be lined and roofed. Lining and covering are certainly desirable improvements, but in view of the financial condition of the city it was unquestionably good public policy to carry out the construction in the manner that has been pursued. There has been trouble in some parts of the city due to flooding of streets, but relief from this situation will come much more quickly if the people will keep trash out of the streets and avoid such public criticisms of the Sewerage and Water Board as tend to increase the difficulty of selling bonds for continuing the improvements.

THE KERN RIVER NO. 1 POWER PLANT OF THE EDISON ELECTRIC CO., LOS ANGELES; PART I.

By C. W. Whitney.

The Pacific Coast, California in particular, has won a goodly amount of renown in engineering circles because of its many note-worthy hydro-electric power plants and its long-distance transmission systems. Going back 14 years to the noted historical work at Redlands and Pomona, practically all the improvements in hydraulic design in connection with high-head plants that have stood the test of time and which mark the best practice of to-day have been evolved in connection with the California water power plants. Substantially the same may be said regarding transmission work; and, although the record for highest voltage has been surpassed quite recently in Michigan, the Golden State still operates successfully the longest lines on the continent.

With this excellent record of pioneer work, and with many modern efficient plants now in continuous operation, it is interesting to note the improvements or innovations incorporated in the design of any new plant. The Edison Electric Co., of Los Angeles, has just completed and placed in operation a station on Kern River, which, while not surpassing any previous records of high head utilized or length of transmission, does employ in its construction many distinguishing features, some of which are distinct departures from previous practice.

In capacity, the Kern River No. 1 power plant equals the rated capacity, 20,000 kw., of the largest impulse wheel plant previously in operation and in overload capacity surpasses it. Its gravity conduit, constructed almost entirely of tunnels excavated through the mountains, is the most permanent and costly hydraulic waterway in the country. The pressure main driven in the form of a tunnel down the mountain slope is probably the most unique feature of the installation and is a decided innovation in power plant construction. The water wheels embody new features in the design of buckets, nozzles and governors. In the electrical details of the station is incorporated the most modern apparatus. The transmission line is at present operated at 60,000 volts and will be raised later to 75,000. The length of transmission, 117 miles, is exceeded in but few instances and the steel towers and insulators are of special design.

Considered in its entirety, or as to its several conspicuous component parts individually, the Kern River No. 1 station typifies the latest modern practice in hydro-electric power plant design and makes timely the following descriptive data. A general description of the plant while it was under construction was given in The Engineering Record of March 18, 1905, and in the issues of February 25 and March 11 of the same year the other plants of this company were discussed.

General Description.—The Kern River is the southernmost large tributary of the San Joaquin River and has its head in the snow-covered slopes of Mt. Whitney, and neighboring peaks of the Sierra Nevada Mts. Water for the plant is diverted at a point ½ mile below Democrat Springs in Kern County and about 14 miles up the river from the mouth of the canyon. An hydraulic conduit consisting almost entirely of a series of tunnels approximately 9 miles in length conveys the water through the mountains on the south side of the river to a forebay at a point about 900 ft. above the river and about 2 miles from the mouth of the canyon where the plant of the Power, Transit and Light Co., of Bakersfield, is located. From the forebay the force main is carried down to the power house in an inclined tunnel.

The power house is located on the bank of the river directly opposite the intake for the Bakersfield plant, and at an elevation of about 20 ft. above the ordinary high water level of the stream at that point. The tail race of the station is designed to deliver the water to the river immediately above the diversion point of the Bakersfield plant. The transmission line is carried down the Kern Canyon and across country to Los Angeles, 117 miles distant.

Diverting Dam.—The dam which is built to divert the water from the Kern River into the hydraulic conduits is placed on bed rock and is carried up to a point 1.25 ft. above the flow line in the tunnel conduit, thus insuring a constant supply as long as the reservoir created by the dam is kept filled. In excavating for the dam, bed rock was found to exist at varying depths, the deepest portions being at the south end at about 35 ft. below the stream bed. A cofferdam was built to divert the river during the construction and while the fill overlying the bed rock was excavated. Trenches were then cut in the bed rock and holes bored in which steel bars were driven in two rows across the canyon. The first layers of concrete were placed on the bed rock and secured to it by means of the trenches and the steel bars. Cyclopean concrete was the material of construction, the rock used being the granite found in the canyon. Many of the rocks were of large size, some weighing several tons each. About 1,500 cu. yds. of material was placed in the foundation, and 3,500 cu. yds. in the dam proper.

Kern River No. 1 Power Plant.

The form of the dam is the overflow type as shown in the accompanying illustration. Its length on the crest is 203.56 ft. and its height above ordinary water level in the river about 20 ft. At the base in the widest part it is 52.81 ft. wide. The crest has a small angle with the horizontal and is 7 ft. in width. The crest and lower face were designed so as to give a true hydraulic curve to the water overflowing and to attain this end the top 15 ft. of the face was built with a batter of 1 to 1 so as to allow an air space under the water. The theory of the design is that air will enter this space under the water from the ends of the dam and that enough will be carried down with the water to form an air cushion. With 2 or 3 ft. of water flowing over the dam a very smooth surface is presented. Below the 45 deg. batter the down-stream face has a radius of 100 ft. The up-stream face has a batter of ¾ of an inch to a foot.

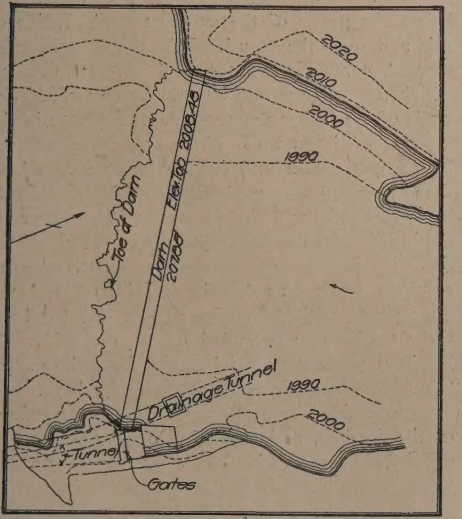
Headworks.—The head or diversion works of the gravity conduit consist of an enlarged or widened section of the intake tunnel with controlling gates operated by means of hydraulic cylinders. In order to prevent contraction as the water enters and to afford sufficient screen area to admit the water, the tunnel is widened out at the entrance to 16 ft. 6 in. The screens or grizzlies are made of slanting bars and extend both in front and on the side of the controlling gate. The bars are ½x3 in. and are spaced on edge 3 in. between centers by means of 2¼-in. thimbles, the thimble rods being 4 ft. apart. The screen is 20 ft. long on the slant and 8 ft. high and is supported on 4-in. cast iron pillars. Behind the screen and just above the gate is a 10-ft. platform on to which can be raked any detritus caught by the screen. The grade at the entrance of the tunnel is increased above the normal so as to excellerate the water from its state of rest above the intake to normal velocity in the tunnel below.

Another important feature of the head works is the drainage or sluicing tunnel, 365 ft. in length, that is driven through bed rock below the intake at the south end of the dam, penetrating to the bottom of the reservoir above the diverting dam. A heavy grizzly built of 70-lb. T-rails protects the entrance of this tunnel and behind are two gates operated by hydraulic cylinders, by means of which the tunnel can be closed or opened as desired. The drainage tunnel was first used to divert the water from above the site of the dam during its construction to the river at a point some distance below the headworks. Its permanent purpose will be to sluice out at such intervals as may be necessary, any accumulation of silt collecting in the reservoir above the dam. The gates of this drainage tunnel are constructed for operation under pressure varying from 35 to 45 ft., depending on the quantity of water flowing over the dam, the hydraulic cylinders for the gate being designed to move them under a head of 20 ft. of water over the dam, should a flood of this magnitude ever occur.

Each of the gate openings is 8 ft. 10¼ in. high and 3 ft. 8 in. wide, the side frames being of cast-iron and the sill a 10x10¾-in. redwood timber. The gates are built up of 5/16-in. steel plates and 6-in. 15-lb. I-beams, the sides being formed of 12-in. I-beams. There are two cast-iron hydraulic cylinders installed for each gate. The set for the east gate is mounted on top of the concrete operating shaft, the west set being placed directly below as there was not sufficient lateral space to place them both on the same level. The lower cylinders are placed 38 ft. 8 in. above the cylinder gate and operate the latter by lifting rods 26 ft. long. The upper cylinders operate their gate by means of 40-ft. rods. These lifting rods are 4½ in. in diameter and are made of wrought iron encased in brass tubing to prevent rusting. The gates are guided at each side by 4 bronze rollers 3 in. in diameter. In order to equalize the pull of the two cylinders on each gate there are installed two racks 10 ft. long and 6 in. wide into which mesh two 12-in. pinions mounted on the top of the gate.

The gates for the intake tunnel are similarly constructed. The hydraulic cylinders both for the intake gate and the sluice gates in the drainage tunnel are operated by means of oil pressure supplied by gravity from a tank on the bank. The oil discharged from the cylinders is pumped up to this tank by a triplex pump, electrically driven, a sufficiently powerful hand-pump being installed for emergency use.

Tunnels.—The hydraulic conduit of the plant is noteworthy by reason of its being the most permanent construction of its character in the country. The Edison Electric Co., after its 14 years practical experience with the construction and operation of hydraulic electric power plants, has profited by the knowledge gained of the different forms of conduit used, such as timber flumes, earthen ditches, concrete-lined ditches, cement pipe and tunnels, and for its Kern River work determined that the most efficient and in the long run economical construction would be a system of concrete-lined tunnels. The expense of driving the tunnels was a large item, but it is warranted in this instance because of the large quantity of water handled and by reason of its permanency and the fact that it will be subject to practically no depreciation losses and but little expense from maintenance. Another important feature of the tunnel construction is that there will be practically no evaporation loss from the conduit. As the evaporation from the natural stream is estimated to be from 15 to 20 per cent. in the summer months, this factor will be an important one during periods of minimum flow. Another advantage of the closed conduit is that no leaves, sticks or other debris can enter the water after it leaves the headworks.

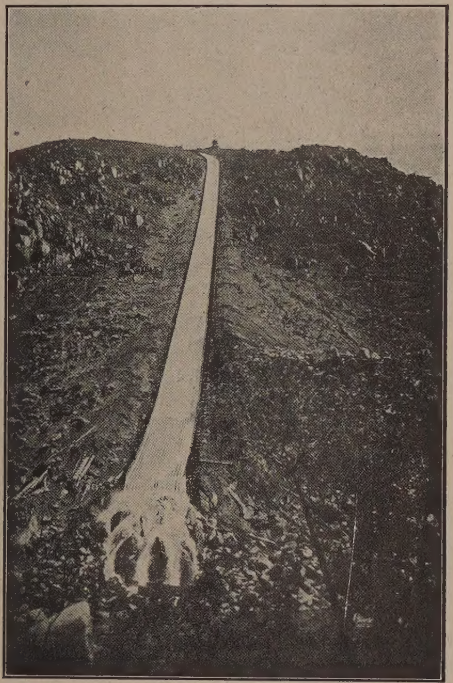


Dam and Tunnel Intake.

Between the intake and the forebay there are 19 tunnels forming approximately eight units of gravity conduit. The tunnels vary in length from 496.3 to 4,373.7 ft., five of them being over 3,000 ft. long, five between 2,000 and 3,000 ft., and four between 1,000 and 2,000 ft. Their combined length is 42,910.5 ft. They are numbered from the intake down, tunnel No. 1 being the intake tunnel, the entrance to which has already been described.

The tunnels were excavated in the rough to be 9 ft. in width and 7½ ft. from the bottom to the springing line of the arch, and 9 ft. in height in the center. Afterwards they were lined with concrete 6 to 10 in. thick on each side and the floor paved with 3 in. of concrete, the net section thus obtained being 8 ft. in width and 7 ft. in height. The entire surface of the side and the floor were covered with a cement mortar plaster ¼ in. thick, composed of 1 part of cement to 2 parts of sand. At the corners of the walls and floor a curve with a 3-in. radius was formed in order to prevent wear at that point and also to smooth up the flow of water.

The section of tunnel adopted is not the most favorable to give the highest velocity on a minimum slope, but it is the most advantageous for the purpose, as by making a wider tunnel greater difficulties would have been encountered with the roof of the tunnel where it passed through a loose or shattered formation. The grade of the tunnel is 7.92 ft. per mile, it being intended that the water should be carried at a depth of 6½ ft. The cross sectional area of the stream is therefore 52 sq. ft., the wetted perimeter 21 ft. and the mean hydraulic radius 2.5.

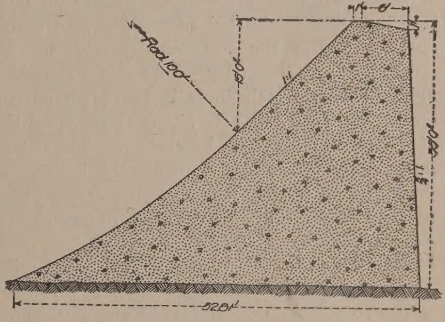


Waste Flume from Forebay.

Assuming the coefficient of roughness to be 0.012 in Kutter's formula, the conduit has a discharge capacity of approximately 470 cu. ft. per second. Judging by experiments made on other tunnels constructed for the Edison Electric Co., and elsewhere, it is likely that the coefficient will not be far from 0.012 for this size of conduit. As is well known, the coefficient of roughness in the Kutter formula should vary somewhat with the mean hydraulic radius and from previous experiments for a hydraulic radius of 2½ and cement plaster as above stated, it will be about 0.012. Observations made during the first day the water was turned into the conduit would indicate that the coefficient would be even less than that value. In places where the tunnels pass through seams and shattered formations or "blocky" ground, they had to be arched overhead in order to support the roof, the concrete at the center of the arch being 12 to 18 in. thick. Less than 15 per cent. of the length of the tunnel required such overhead arching. Where this was necessary it was placed by using a template, with lagging overhead, the concrete being thrown back and tamped into place above the lagging. In excavating through this blocky ground timbering was necessary, the standard bent being formed of 6x8-in. sets spaced 4 ft. centers and holding the rock back by 3-in. plank. In such sections the timber was left in position and completely covered by concrete. The concrete at the sides was tamped into place behind boards supported by vertical forms. Wherever large cavities had been blasted out in driving the tunnels, these were built with rip-rap, the interstices of which were filled with sand and gravel. The same method was pursued above the concrete in the arches. Consequently there are no cavities existing between the bed rock and the concrete lining in the tunnels.

In several places springs were encountered and as the pressure that would be created by stopping them up might be disastrous to the tunnel lining, vents were installed through which the water can flow into the tunnel. These vents consist of sections of pipe from ¾ to 3 in. in diameter and 6 to 8 in. long, set in the floor or wall and left open at both ends. The spring water being under higher pressure than that flowing in the tunnel, continues to flow into the tunnel and thus relieve it of any strain.

The excavation of each of the 19 tunnels was carried on from both ends, thus dividing the work up among 38 headings. The work was principally done by pneumatic drills with 3¼-in. cylinders. Some hand work was done in opening up approaches and adits and where loose formation was encountered. The ardinary progress in driving with pneumatic drills was 5 ft. for a 10-hr. shift, using 2 machines in the face. This varied considerably, however, as the number of holes required for breaking the ground varied from 10 to 24. The depth of the holes usually employed was as follows: cut-ins, 8 to 9 ft.; lifters, 6 to 7 ft.; breast holes 6 to 7 ft.; back holes, 5 to 6 ft. The amount of powder consumed also varied according to the formation, so that no stated quantity per round of holes can be relied upon. In the toughest rock encountered it was sometimes found necessary to reload the holes the second time in order to break the ground, the first blast blowing out the rock only at the upper end of the hole.



Diversion Dam.

The pneumatic drills were supplied with compressed air by means of 3 and 4-in. steel casings laid from the six construction camps located at suitable points along the canyon between the power house and the intake. Ventilation was provided by means of motor-driven Root reversible blowers located at the tunnel or adit openings and connected with the working faces by means of galvanized iron stove pipe. The company carried on all the tunned excavation work itself, the only contract work being that for teaming, the supply of provisions, and feeding the men. By this method the company has been able to secure construction data which will be invaluable to it in carrying on similar work in the future and in the consideration of contract work. The only contract work done on the tunnels was the concrete lining. This was done by Glass & Fischer, of Los Angeles and Redlands, this firm also contracting for the boarding houses.

Standard and Colton brands of Portland cement, supplied by the two California mills, were used throughout for the concrete, the mixture being in the proportion of 1:3:5. For the sand and aggregate the granite excavated from the tunnels was used. The rock was crushed to 1½ and 2 in. size, and for the sand it was crushed and rolled so as to pass through a 60 screen. Gates gyratory and Blake jaw crushers and Buchanan 10-in. rolls were employed. As no adequate water supplies were available along the route of the conduit, the water necessary for mixing the concrete had to be pumped up from the river, Rumsey duplex pumps being employed for that purpose. For mixing one Smith and two Ransome mixers were used. The men were worked on two 9-hr. shifts, illumination being furnished by a construction power plant to be mentioned later. A total of 110,000 ft. of lumber was used in the forms for the concrete work.

After the tracks had been removed from the lower tunnels and when the roads from the upper camps were impassable because of heavy rains and snow, two automobile wagons were purchased and proved indispensable in carrying cement and other supplies through the finished tunnels from camp 1 to the upper tunnel. These machines were of the Lambert friction drive type and were equipped with 20-h. p. gasoline motors. The wheels were fitted with heavy hard rubber tires. About 7,000 bags of cement were thus transferred from camp 1, an average distance of 5½ miles. In all about 1,000,000 lbs. of freight was carried by the two machines. Even the steel rails for the construction track were carried out in the automobiles. With light loads a speed of about 18 miles an hour could be made, precautions being taken at curves which were indicated by white signal flags.

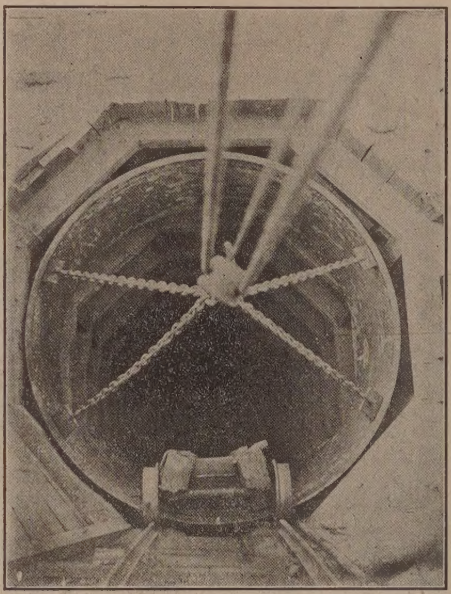
After the tunnels were completed 2-wheeled hand-carts with rubber tired wheels were used for carrying cement and light tools for such finishing and repair work as was necessary. They were also brought into service in stringing the telephone line that is carried throughout the entire tunnel, connecting the power house with the diversion works at the dam. The two galvanized iron wires of this telephone line are carried on inverted T-shaped brackets about 10 in. from the roof of the tunnel. The brackets are formed of ¾-in. pipe with porcelain insulators bolted on each end of the horizontal arm. The vertical pipe is secured in the holes of the rock or cement by wooden plugs.

Timber Flumes.—The tunnel work was planned so as to avoid wherever possible flumes for spanning the side ravines encountered along the line. However, in order to maintain a good alignment and make the line as short as possible, a few exceptions had to be made to this rule. Some of these ravines leading down to the main canyon and crossing the line of the conduit were on such a flat slope that should the tunnel be constructed under the ravine the necessary adits would have been very long. This not only would have increased the cost materially, but also would have added to the length of the line, and the time required to do the work. At such points where there was no danger from falling rocks the ravines were spanned with flumes. There are six of these flumes, the longest being 1,029.6 ft. long and the others vary in length from 49.9 to 167½ ft. All except No. 3, which is built of reinforced concrete with a steel frame, are constructed of timber. They are placed on concrete foundations and are designed with a factor of safety sufficient to make their life from 30 to 40 years. The framework for supporting the flume box is of Oregon pine, being so designed and distributed that no part of the timber comes in contact with the earth or is exposed to the drip should the flume at any point spring a leak. In this way the life of the Oregon pine will be great, as it is invariably kept dry and free from contact with the soil.

The flume box is built up of 3x12-in. redwood planks obtained from butt ends of Sequoia Semper Virens, grown in swamp lands west of the Coast Range in northern California. The grade of this lumber is perfectly clear, and its quality is such that its life should not be less than 40 years. The edges of all planks were bevelled so as to give a ¼-in. opening on the inside of the joints which is caulked with ship chandler's oakum. The bottom seams were covered with hot asphaltum and 1x6-in. redwood battens nailed down over them. On the sides of these flumes a specially designed batten is used. This batten is of 1x6-in. redwood, the upper half being cut away on a curve, permitting asphaltum to be poured between the batten and the side of the flume. At the corners of the flumes a quarter round strip is nailed.

The design of the flume above described has been thoroughly tested and even if it should stand dry for months in the hottest weather, the designers state that it may be again filled with water without having any perceptible leakage.

In some of the flumes where streams are crossed that are apt to carry considerable water in winter, span flumes are constructed. One of these span flumes has a length of 32 ft., built with a 10x12-in. timber frame and resting on 12x12-in. beams. In connecting the wooden flume with the portal of a tunnel, a construction of a special nature was used, which offers two points of contact between the wood and the concrete and a well between the two, from which the water may be pumped out and any leaks repaired should these ever occur between the wood and the concrete.



Lowering 90-Inch Pipe Down Shaft.

Steel Concrete Flume.—The flume between tunnels 6 and 7 across Laird Canyon, is constructed of structural steel and concrete. The whole structure is carried on 15-in. steel I-beams set 8 ft. 10 in. apart and supported by concrete piers. These longitudinal girders carry 9-in. steel I-beams laid transversely 4 ft. center to center and on them is erected a framework of structural steel for the sides and bottom of the flume. Two layers of expanded metal of 1½ and 3-in. mesh are used in connection with this framework, and being filled with concrete form the plates enclosing the frame. This concrete construction is also reinforced on the floor by twisted ½-in. rods. The outside and inside of the flumes were then plastered, making the thickness of the reinforced concrete sides and bottom 4 in.

This type of flume or conduit had never been tried before, but in this case has proven a decided success and while it costs more than a wooden flume it has the advantage of being as permanent as the tunnels themselves.

Concrete Conduits.—In the lengths of tunnels and flumes forming the gravity conduit enumerated above no account is taken of the concrete conduits which connect some of the tunnels with the flumes. There were places along the line where the tunnel emerged at the foot of a steep incline in such a manner that the flume if constructed on the grade would be threatened by land-slides or boulders rolling down the side of the mountain. These places were spanned by means of concrete conduits, the interior of which have the same cross-section and slope as the tunnels themselves. The walls are made heavy and reinforced with steel and an arch overhead, the arch being covered with a cushion of earthen material to receive the impact of anything rolling or sliding down the hill and passing over the conduit. There are eight of these conduits having an aggregate length of 503½ ft., and with the exception of a very short one vary in length from 31.6 to 121.6 ft.

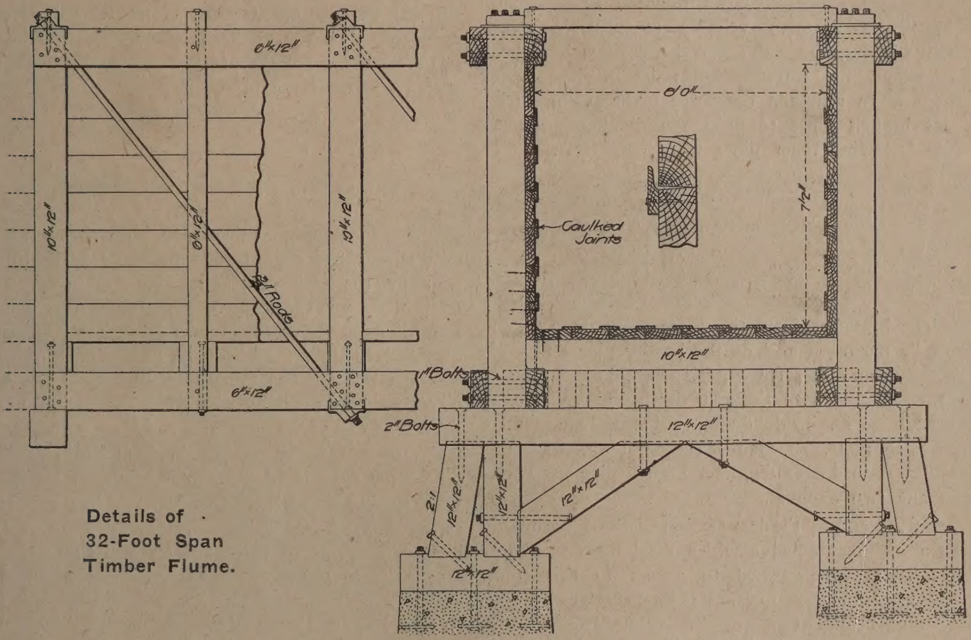
Forebay.—A terminal equalizing reservoir of some size at the end of the gravity conduit and feeding the pressure main would have been desirable in connection with the project. However, the slope of Mt. Breckenridge, where the lower end of tunnel 19 emerges above the power house, is approximately on a 45-deg. angle, making it impossible to excavate any large area for a tunnel reservoir or forebay. It was necessary, however, to have a small basin for regulating the flow in the force main and for this purpose a chamber 30x42 ft. was excavated to a depth of about 8 ft. below the grade of the supply tunnel. Inside of this and over the mouth of the force main were erected controlling gates and screens through which the water passes into the force main. The walls of the forebay were made of concrete in the form of retaining walls where they were enclosed in the excavation and on the lower side where they were unsupported were made sufficiently heavy to withstand the pressure of the water on the inside. As the formation where the construction is located is somewhat shattered the concrete work was heavily reinforced and the floor paved with 3 ft. of concrete. At the back these walls were extended up to a considerable height to prevent material caving from the mountain above from dropping into the forebay.

On one side is a spill-way 9 ft. above the floor of the forebay, and consisting of five 6-ft. 10-in. openings over which the water flows into the waste flume when it is desired to divert part or all the tunnel flow from the pressure main. The height of this spill-way can be controlled by means of flash boards which may be inserted and removed as required, according to the quantity of water carried through the tunnels. The extreme height of the spill-way is 3 ft. A 24-in. gate valve is set at each end of the spill-way for sluicing into the waste flume.

The force main starts from the bottom of the forebay, thus making it possible to have the water enter it from opposite directions. This construction tends to prevent the formation of eddies or a whirl-pool at the entrance.

The controlling gates have an opening of 6 ft. 2 in. high and 10 ft. wide and are built up of 4x12-in. timbers on two vertical 6-in. steel I-beams. They are raised by means of hand-operating gearing through four sets of gears working in two racks, 7 in. wide with 3-in. pitch, mounted on the front of each gate. Behind the gate and inclined upward toward each other are two heavy grizzles. These are formed of 3½x½-in. iron straps, spaced 3 in. on centers by thimbles of 2½-in. wrought iron pipe, the rows of thimbles being set 1 ft. apart. Each screen is 11 ft. 6 in. long and is set on an angle with its top supported by a 4-in. steel I-beam. These two beams are 3½ ft. apart, the space between forming a walk.

Waste Flume.—The forebay is constructed so that when the water is diverted from the force main it passes over the spill-way automatically into the waste conduit extending down the mountain side to the river. This conduit is of concrete at the upper end where it is on a comparatively flat grade, the section being 8 ft. wide and 8 ft. 6 in. high. The water is discharged into a redwood flume 20 ft. wide that carries it down the steep slope of the hill. As the slope is about 45 deg., only soft wood, it was believed, would stand the wear due to the high velocity. The spill-way flume is 1,200 ft. long and discharges into the Kern River about 600 ft. above the power station. It rests on 4x6-in. stringers bolted to 3x3x3/8-in. anchor plates embedded in concrete footings. These footings are spaced 8 ft. apart and are securely set, although they are not carried down to bed rock in all cases. The cross-beams of the flume are 4x6-in. timbers 26 ft. 6 in. long. The side posts are 4 in. square and are carried up 3 ft. 3 in., being secured at the bottom by angle plates. They are set 4 ft. center to center and are angle braced by 4x4's, bolted at both ends by ½-in. bolts. For lining the flume 2x12-in. redwood planks were used, the joints in the floor being calked and covered by 1x6-in. battens. Quarter rounds were nailed in the corners as in the other flumes. The side lining, which is carried up 3 ft. high, is battened and caulked in the same manner as already described for the smaller flumes.



Details of 32-Foot Span Timber Flume.

Pressure Mains.—The greatest innovation in the entire plant is the pressure main, the construction of which has been along new lines and in decided contradistinction to the customary practice of laying a steel pipe on the surface of the mountain slope or merely burying it sufficiently to cover it for protection against freezing or expansion and contraction such as might be caused by a wide range of temperature changes. The pressure main constructed on Kern River consists of a tunnel approximately 1,700 ft. long driven through the mountains on an incline and lined with steel varying in thickness from 3/16 to 1½ in. This tunnel begins at the bottom of the forebay and is carried down at an angle of approximately 45 deg. and turning into the horizontal section emerges at the lower end on a level with the floor of the power station. There are 3 vertical curves in the tunnel. The upper one forms an angle of 7 deg., 260 ft. from the forebay floor and turns the pipe from a grade of 130.32 per cent. to a grade of 101.35 per cent. The second curve 32.5 ft. lower down has an angle of 5 deg. and turns the pipe into a grade of 84.93 per cent. on which it is carried 994.24 to the last vertical curve. The latter has an angle of 40 deg., and from its lower end the pipe is carried along horizontally to the power house, the total length of the main being 1,697 ft.

The pressure main is finished to give it an inside diameter of 7 ft. 6 in. At the top a taper 20 ft. long and 10 ft. in diameter at the forebay entrance terminates in the regular 7½ ft. diameter of the completed tunnel tube. This diameter of 7½ ft. is maintained throughout the inclined tunnel and on the horizontal beyond vertical curve No. 3 for a distance of 167.39 ft. At this point 1,454.44 ft. from the forebay, the force main emerges from the solid rock and is carried to the portal a distance of 243 ft. through a detrital deposit lying between the mountain and the power house site. Where the tunnel emerges from the solid rock a 20-ft. taper was installed, reducing the diameter of the main from 7½ to 5¼ ft., at which diameter the pipe is carried to the branch piping at the power house.

The inclined part of the pressure main and the portion of the horizontal section that is carried through solid rock were finished by installing a steel lining built up of plates 3/16-in. thick for the incline and 3/8 in. thick for the horizontal, riveted together to form a cylindrical pipe 7½ ft. in internal diameter. The tunnel itself was driven in approximately circular form and 9 ft. in diameter. The steel pipe was centered in the tunnel, being installed in 10-ft. sections and the space between the outside of the steel lining and the bed rock was thoroughly filled with a mixture of 1:3:3 concrete. The work of installing this lining was begun at the lower end in the horizontal section where the pipe is tapered down to a diameter of 5¼ ft. At this point the 20-ft. taper already mentioned was placed. It consisted of 1⅜-in. steel plates riveted together with butt straps. The taper was placed back in the solid rock and around it was constructed a heavy bulk-head of concrete which was anchored into the bed rock by means of steel rods driven into the sides.

From this point the installation of the light steel lining with concrete back-fill as already stated progressed from the bottom to the top of the tunnel terminating at the reinforced concrete taper that connects with the floor of the forebay. The rock formation through which the force main tunnel was driven is not of the best kind, being very much fractured and broken. It was necessary to timber the greater part of the shaft or incline when it was excavated, and these timbers had to be removed before the steel lining was installed. The timbers were removed ahead of the steel work, the bed cleaned off and the concrete tamped into place without difficulty. At a point about 120 ft. below the top, the men in charge removed some timbers without bracing the bents above. This precipitated a cave-in of the shaft and several men lost their lives, one man being imprisoned for two weeks, after which time he was rescued in good condition. In retimbering the caved portion octagon steel sets of 7-in. 15-lb. I-beams were used, these sets being left in place when the concrete was filled in behind the steel lining.

The lower end of the pressure main, below the taper reducing the diameter to 5¼ ft., was made of 1⅜-in. steel plates sufficiently heavy to withstand the static pressure without any external support. No concrete was placed around this pipe, and the tunnel was merely left in its original condition with the timber set to support the ground overhead.

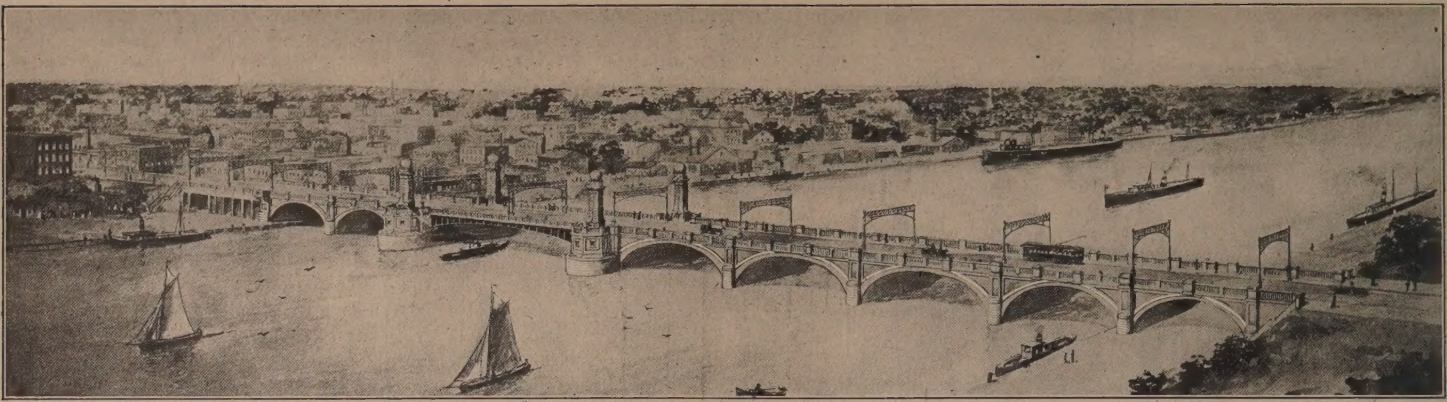
At a point 215 ft. above the power house, a man-hole was placed in the inclined tunnel for convenience in inspecting and for use in case any repair work was necessary. The regular 3/16-in. steel lining was replaced at this point by a section of 1½ in. pipe 30 ft. long.

The steel pipe was shipped to Camp No. 1 at the power house from San Francisco in 5-ft. lengths, 5 sections being nested together for shipment. The outside section was riveted complete on its two longitudinal seams but the 4 inner sections were riveted on one seam only, so as to allow for the nesting. At the camp the pipe was riveted into 10-ft. lengths and hoisted by means of an aerial tram to the forebay site at the upper end of the pressure tunnel. There the sections were secured to a dolly car and lowered by means of a hoist to the point where they were riveted together. This car consisted of a truck at each end of the pipe sections, the latter being hung from two timbers that passed through the pipe and rested on the axles of the truck, as shown in one of the illustrations.

All the piping in the pressure tunnels which is constructed of steel plates of ½-in. thickness and under is made up with standard lap joints, double riveted on the longitudinal seams and single riveted on round seams. All pipe on the work over ½ in. in thickness is made up of butt-strapped joints throughout with triple riveting on each side of the longitudinal seams and double riveting on each side of the round seams.

After the steel lining was completed an inspection of it revealed the fact that there were several places along the bottom of the pipe where voids had been formed in the concrete backing. These voids which were revealed by tapping were caused mainly by the difficulty experienced in tamping the concrete thoroughly around the steel lining. These steel sections were 10 ft. in length and in a few places where large irregular rock excavation occurred at the bottom of a section with but a 9-in. space at the top for handling the tamping bars, some voids were naturally formed because of the insufficient tamping.

Whenever these voids occurred, the pipe was tapped and liquid cement forced until the hole was filled. The apparatus designed on the spot to accomplish this work was an ingenius one. A section of 3-in. steel tube 20 in. long was fitted at the bottom with a cap that would fit the hole drilled in the steel lining. Liquid cement was poured into the void by means of this pipe, which had a capacity of about an ordinary pail. When no more cement would run in there was fitted in the pipe a screw with a plunger at the lower end and a crank at the outer end. By means of this device the cement was forced into the void under pressure until it would hold no more. The pump was then removed and the hole in the lining was stopped up by an ordinary flush pipe plug. There were 116 of these voids tapped and filled through the lining, although but three of them were of any size.



The Proposed Cherry Street Bridge across the Maumee River at Toledo.

A number of the voids required but a pint of the liquid cement, the quantity used varying up to the largest for which ten buckets of the slush was necessary. The slush used was a liquid mixture of Portland cement and sand. The work was carried on from a dolly car fitted with bevelled wheels and lowered down from the top by a steel cable. About 15 days were necessary to complete this special work. After all the voids were filled the entire pipe was painted with asphaltum, the same dolly car being used for the purpose.

Although the design of the pressure main has been criticised by some it is believed that the structure will stand criticism and will prove to be permanent and for that reason economical. The steel lining has a low factor of safety, being only heavy enough to keep its form and resist the internal pressure, while all external pressure is taken up by the concrete back filling, which backed by the rock itself also resists the internal pressures. Being entirely underground and some distance from the surface no trouble will be experienced by reason of expansion and contraction due to temperature changes. The anchorage is a mountain itself so no disastrous effects could result to the pressure main from any water ram that might be caused by improper handling of the water wheels or gate valves.

Branch Piping.—At the lower end of the pressure main was constructed the header pipe made of steel plates, varying in thickness from 1⅜ to ¾ in. at the outer end, and consisting of the following lengths and diameters:

PIPES FOR HEADER.

Length.	Size of Pipe.
33.5 ft.	4¾ ft.
23.0 "	4¼ "
21.0 "	3¾ "
11.5 "	3 "
16.7 "	2⅓ "

These diameters were graduated to maintain as nearly uniform velocity as possible after withdrawing the water for the various branches to supply the water wheel units in the power house. In reducing the force main at the various branch pipes to meet the diameters given, the following taper pipes were employed:

TAPERS FOR HEADER.

Length.			
20 ft.—	Tapering	from	7½ to 5¼ ft.
10 ft.—	"	"	5¼ to 4¾ ft.
10 ft.—	"	"	4¾ to 4¼ ft.
10 ft.—	"	"	4¼ to 3¾ ft.
10 ft.—	"	"	3¾ to 3 ft.
10 ft.—	"	"	3 to 2⅓ ft.

The branches from the force main were taken off by means of a Y on the header pipe and laid out in curved form entering the power house at right angles to the rear well. There is one branch 28 in. inside diameter 50 ft. long, made of ¾ in. plate, for each of the eight water wheels and a 10-in. inside diameter branch pipe for each of the two exciters.

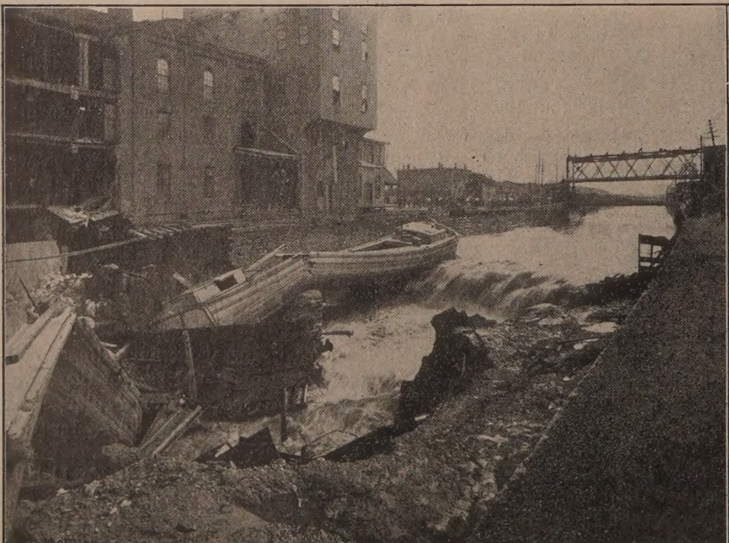
At the end of the last section of the force main is a 28-in. gate valve which discharges into the river. It is proposed to attach to this pipe an experimental nozzle for the purpose of testing nozzle tips, needle valves and similar apparatus and it is expected from such tests data will be obtained regarding the flow of water under varying conditions. In each of the branch pipes leading from the force main to the water wheels are installed two 28-in. gate valves, one outside of the power house and the other inside. The former is intended solely for the purpose of closing off the branch pipe in case of any repairs to the gate or piping. The outside gates are arranged only for hand drive, while those inside of the power house are equipped for operation either by hand or by electric motors as will be mentioned later. The Risdon Iron & Locomotive Works, San Francisco, furnished the steel lining for the pressure main, the branch piping and header, and the gate valves.

(To be Continued.)

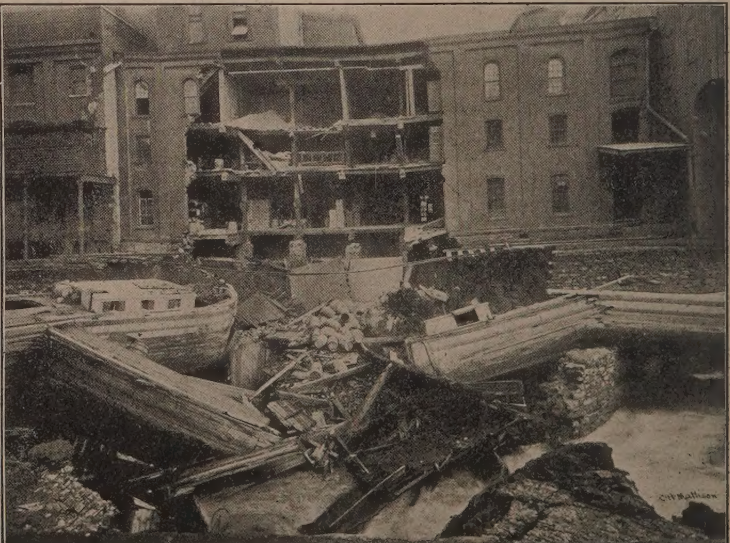
The Cherry Street Bridge, Toledo.

The acompanying illustration shows the general appearance of a bridge designed early this year by the Osborn Engineering Company, of Cleveland, for the Cherry Street crossing over the Maumee River at Toledo. The total length of this bridge over all is 1,184 ft., and the width of the river between the established dock line is 900.1 ft. The roadway for which provision has been made is 52 ft. wide and there are two sidewalks of 9 ft. each, making the total width 70 ft. The draw span is of the simple trunnion bascule type, resting on piers 40 ft. wide, and has a clear opening of 200 ft. The masonry arches have various spans, three of them 108 ft., and the others from 66½ to 100 ft.

The Brush Creek Viaduct on the Alabama extension of the Illinois Central R. R., is a structure 1,231 ft. long and having a maximum height of 171 ft. 2 in. from the masonry footings to the base of the rail. The total weight of the structure is 1,943 tons. The structure consists of ten 75 ft. deck plate girder spans, nine towers with 40 ft. deck plate girder spans, and two 60 ft. deck plate girder approaches.



View of Erie Canal Break, Looking West.

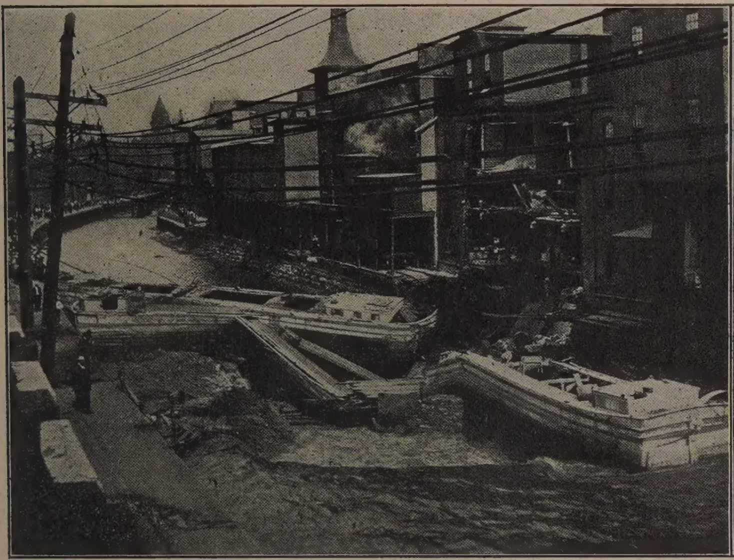


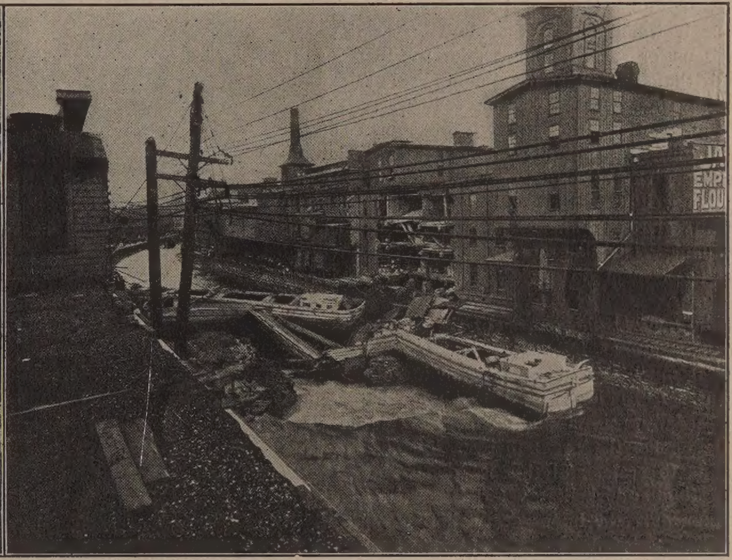
View of Erie Canal Break, Looking South.

The Syracuse Break in the Erie Canal.

An unusual accident happened to the Erie Canal at Syracuse, N. Y., on July 30. The Onondaga Creek flows under the canal at this place through three stone culverts about 175 ft. long. The west and middle culverts have 25 1/3 ft. span, 6 3/4 ft. rise and abutment walls about 6 ft. high. The arch stones are 2 ft. in depth at the crown, increasing to 2½ ft. at the springing lines. The east culvert is about half the size of the others. The arch of the west culvert probably failed first, under the brick wall of a flour mill, which pitched into the canal. The break extended some 50 ft into the canal, and the stone retaining wall along the south side of the canal caved in for a distance of about 100 ft. The bottom of the canal was washed out 10 to 20 ft. deep for a distance of 150 ft. The general appearance of the canal after the accident is shown in the accompanying illustrations.

At the present writing it is impossible to state just what was the cause of the accident, for the wall of the Amos mill, the wreckage of two canal boats and a great mass of debris cover the ruins of the masonry. It is conjectured by some local engineers that water from the tailrace of the Amos mill, which entered the creek in close proximity to the culvert, probably undermined the foundations and was the direct cause of the accident. It is expected that repairs will be completed in the course of a fortnight.


View of Canal Break, Looking Southeast.



View of Canal Break, Looking East.

A RAPID ORE CAR UNLOADER has recently been installed on the Duluth ore docks of the Duluth, Missabe & Northern R. R., to replace manual labor in breaking up or dislodging the ore in bottom-dumping ore cars when discharging into storage pockets. A traveling crane spans the unloading tracks above the pockets, the cross traveling trolley of which carries vertically adjustable racks of blades which may be forced down into the load of ore in a car with a pressure of 8 tons. Then by the longitudinal movement of the bridge, the blades may act as a sweep to clear the car of contents from either end to the hopper. All three movements of the crane are electrically operated so that the blades may be rapidly spotted over any car on any of the unloading tracks. These machines operate continuously in all conditions of weather and unload the cars at the rate of one car per minute, each machine replacing a large number of men and enabling the work to be carried on continuously throughout the 24 hr.

Tests of Concrete Columns.

A paper read before the American Society for Testing Materials by Arthur N. Talbot, professor of municipal and sanitary engineering and in charge of theoretical and applied mechanics, University of Illinois.

Before taking up a discussion of the recent experiments, I desire to modify a statement made in a discussion of this subject at a meeting of the Society a year ago, since the form of the printed discussion may be misleading. The remark was made that in the tests of reinforced concrete collumns made at the University of Illinois there was indication that the steel buckled before the ultimate strength of the columns was reached. Further study of the tests shows that the steel did not buckle or reach its elastic limit until after the load taken by the concrete had reached its maximum, although in a few instances the load sustained by the column when the rods buckled, was equal to or a little greater than the load when the concrete was seen to be taking its maximum stress. Fig. 1 gives the stress-deformation diagram for one of the columns. The line marked "Line for steel" represents the stress in the steel as though distributed over the full area of the column, based on the observed deformation in the column and a modulus of elasticity of 30,000,000 lb. per square inch for the steel, under the assumption that the concrete and steel act together. The line marked "Line for concrete alone" was found by setting down the line for concrete and steel (*i. e.,* for the column as a whole) an amount equal to that given by the "Line for steel." The line for concrete obtained in this way corresponds closely with the line obtained in tests of plain concrete columns. This diagram gives a convenient method of comparing the stress taken by the steel with that taken by the concrete, if we assume that the stress in the steel is proportional to the shortening of the column. The ratio between the unit stress taken by the steel and that taken by the concrete at any stage of the loading of the column, based on the above assumption, for the column tested, is shown in Fig. 2. The average value for this ratio at the beginning of loading is 13; at three-quarters of the maximum load (corresponding to one-half the ultimate shortening) it becomes 18, and at the maximum load 26. The extreme range of this ratio for the individual columns is considerable. It may be also added that in these tests the strength of unreinforced columns was considerably less than the strength of 12-in. cubes made at the same time. A more complete discussion of these tests may be found in a bulletin of the Engineering Experiment Station of the University of Illinois.

Passing now to the tests which have recently been made at the University of Illinois, it should be stated that only a summary of the results will be given here and that a more thorough study of the tests will be made later. The tests include three classes of columns: (1) plain or unreinforced concrete columns, (2) columns reinforced with circular hoops or bands, and (3) columns reinforced with wire in the form of spirals or helices.

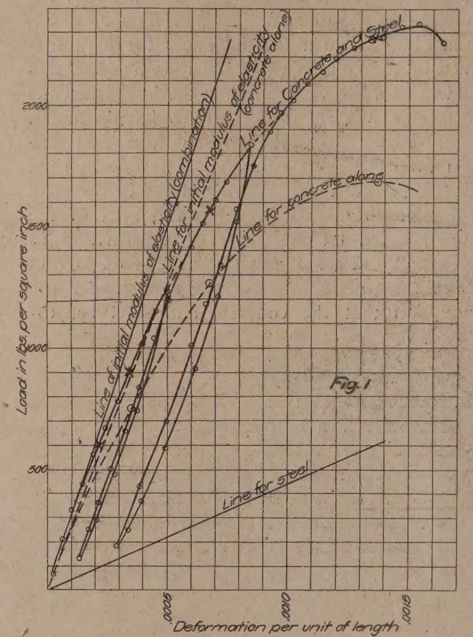
The concrete used, unless otherwise stated, was composed of one part of Portland cement, two parts of sand, and four parts of broken stone, by loose volume. A detailed description of the materials and of the method of mixing will not be given here. The columns were fabricated in galvanized iron forms. The concrete was a wet mixture, wet enough to allow stirring or churning in the forms. The forms remained in place for ten days. The columns were built on cast-iron base plates, and an upper base plate was embedded in plaster of paris on the top of the column a few days before the test. The average age at test was about 60 days. The columns were circular, 12 in. in diameter and 10 ft. long. A few were made 9 in. in diameter. In order not to complicate the analysis of strength, the hoops and spirals were barely covered at the surface of the column, the thickness outside the hooping being generally less than ¼ in. The area of the column was taken to be equal to the area corresponding to the diameter of the hooping. The circular bands used for hoops were 1 in. wide and of three thicknesses, No. 8, No. 12, and No. 16 gauge. The yield-point of this material was about 48,000 lb. per square inch. The hoops were electric welded. Tests of the hoops usually showed failure outside of the weld. In the few cases where failure occurred at the weld the breaking load was beyond the elastic limit of the steel. Generally the hoops were spaced 2 in. apart, center to center, although in some columns the spacing was 3 and 4 in. The spirals were No. 7 wire and ¼-in. wire. Ordinary black wire and high-carbon steel wire of both sizes were used. Considerable difference was found in the elastic limit of the high-carbon material; the smaller size gave about 60,000 lb. per square inch, and the larger size 110,000 lb. for the yield-point. For the black wire the yield-point for the No. 7 was 38,000 lb. and for the ¼-in., 54,000 lb. No longitudinal reinforcement was used. The thin longitudinal spacing bars used to hold the hooping in place were not considered in the calculations. In the statement of amount of reinforcement the percentage is based upon the volume of the hooping and the volume of the concrete core; or what is the same thing, upon the area of the hooping considered to be uniformly distributed over the length of the column and the area of the concrete core.

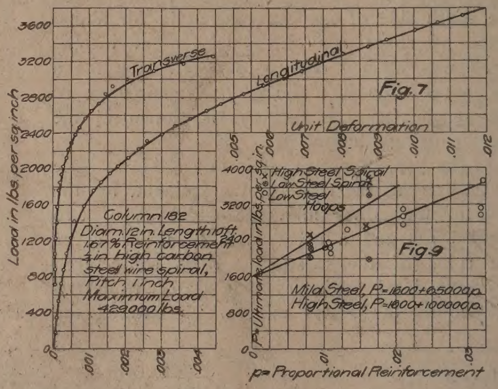
The plain concrete columns gave results similar to those tested a year ago, both in the ultimate strength and in the character of the stress-deformation diagram. The strength of the 1:2:4 columns averaged about 1620 lb. per square inch, with a range of variation of 30 per cent. on either side of this. The stress-deformation diagrams approximate a parabola, but the total shortening at failure was somewhat less than that given in the 1906 tests. Fig. 3 gives a diagram for one of the columns. An interesting feature of these tests was the determination of the lateral deformation or enlargement of the column. The measurement of this expansion is extremely difficult, and this work is of an experimental nature and the results are not to be considered final. Further study of the data will be required to interpret them fully. It seems, however, that the value of Poisson's ratio found from these tests is generally less than that given in text-books. This is particularly true for the smaller loads. The ratio increases rather suddenly somewhat before the maximum strength of the column is reached. The line at the left of Fig. 3 gives the amount of the lateral unit-deformation. From a hasty study of the results it would appear that Poisson's ratio averages 0.1 or somewhat more, for the lower loads, and that near the maximum load this ratio rapidly increases to 0.25 or 0.3.

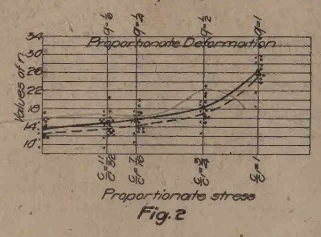
Fig. 4 gives the strength of columns made with different mixtures of concrete. The abscissas give the proportion of cement in terms of the weight of the sand and stone used. The results given are the average of two to five test columns. The diagram brings out the effect of adding cement in giving strength to concrete columns.

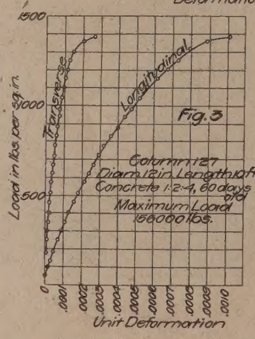
The general phenomena of the tests of hooped columns are as follows. The early part of the test is much the same as for plain concrete columns. At a load equal to that which would cause failure in a plain concrete column or a little above, the concrete over the spacing bars begins to scale, and this is soon followed with a scaling and shelling off of the surface of the column over the hoops everywhere. With added increments of load the amount of shortening increases rapidly and the column correspondingly expands or bulges laterally. The lateral deflection of the column from a straight line begins to be apparent just before the maximum load carried by the column is reached, and it rapidly increases after the maximum load is passed, forming a curve having the characteristics of the figure shown in text-books for columns with fixed ends. The columns finally bent out of line, in some cases as much as 4 or 5 in., the load finally carried being only a small proportion of the maximum.

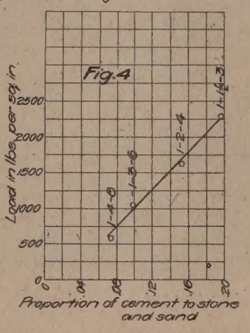
Fig. 5 shows the stress-deformation diagram for a column reinforced with circular hoops and may be considered to be characteristic. In this and in the other columns, the load carried when the column had shortened an amount equal to that which plain columns exhibit at failure corresponded to the maximum load of plain concrete columns. If the line beyond the elbow (approximately straight) is produced to the vertical axis or axes of ordinates, the load there indicated agrees closely with the maximum strength of plain concrete. The diagram indicates that up to the load where a plain concrete column would fail, the shortening and the lateral deformation correspond closely with those obtained for plain concrete columns, and but a small stress is developed in the hoops. The line at the left of the figure gives the lateral unit-deformation. Beyond the critical point referred to, the longitudinal deformation or shortening increases rapidly with an increase of load, and the lateral deformation increases correspondingly. The total amount of shortening is considerable, in this column being nine times as much at the maximum load as may be expected in a plain concrete column at its maximum load. The maximum strength of the columns occurs when the bands have been stretched to their yield-point. Beyond this point the deformations increased rapidly, but the load falls off Fig. 6 gives a view of one of these columns after the outside scale has fallen off and some time after the maximum load has been applied.











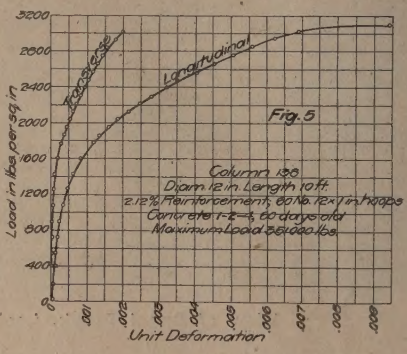


Fig. 1, Stress-Deformation Diagram for Column with Longitudinal Reinforcement. Fig. 2, Ratio of Stress in Steel to Stress in Concrete. Fig. 3, Stress-Deformation Diagram for Concrete Column. Fig. 4, Effect of Mixture on Strength of Concrete Column. Fig. 5, Stress-Deformation Diagram for Hooped Column. Fig. 7, Stress-Deformation Diagram for Column with Spiral Reinforcement. Fig. 9, Strength of Hooped Columns.

Fig. 7 gives the stress-deformation diagram for a column reinforced with high-carbon wire. The early part of the diagram is similar to that already described. The total amount of shortening is greater, as may be expected from the higher elastic limit of the reinforcing. The total shortening at the maximum was 13 times what may be expected in a plain concrete column at the time of failure. The lateral deformation curve shown at the left of the figure cannot be compared with the former one since the instruments were placed on the concrete between the wires and, as would be expected, the lateral swelling at these points is greater than for the reinforcement itself. Fig. 8 gives a view of one of these spirals after the maximum load had been applied.

The results indicate that the strength of the columns is dependent upon the strength of the concrete mixture, the amount of the hooping reinforcement, and the yield point of the reinforcing. In other words, the additional strength over that of plain concrete columns is a function of the amount and strength of the reinforcing. In Fig. 9 are plotted the strength of the hooped columns, and the amount of hooping. The lower line may be considered to represent the strength of the columns with mild steel hooping. Its equation is $P=1,600 \div 65,000p$, where p is the ratio of the hooping to the concrete core. The upper line is for hooping, having a higher elastic limit. Its equation is $P=1,600 \div 100,000p$. The columns reinforced with wire having a yielding-point of 110,000 lb. per square inch, gave a still higher strength and, of course, a greater amount of shortening. Equations of the same general nature may be derived from the results of other experiments on hooped columns. The first term represents the strength of plain concrete columns. These equations are given tentatively as expressing the results of these experiments.

It may be of interest to note the relation which exists between the load or longitudinal pressure on the column and the lateral pressure which may be considered to act on the hypothesis of hydrostatic pressure to give the deformation of the mild steel bands. Such of these tests as have been studied indicate that this hypothetical lateral pressure amounts to about 0.35 of the longitudinal pressure acting in excess of the strength of the plain concrete. Comparing the effect of hooping with the additional strength given by longitudinal reinforcement with concrete of the same character (counting in the latter case that the stress in the steel at the ultimate load is twenty-five times as great in intensity as the stress in the concrete), it appears that the additional strength produced by a given amount of reinforcing material is from two to four times as great for the hooped columns as for columns with longitudinal reinforcement. Attention should be called to the fact that since the shortening in a hooped column at the maximum load is several times as great as in a column with longitudinal reinforcement at the yield-point of the steel, the effect of combining longitudinal reinforcement and spiral hooping is uncertain.

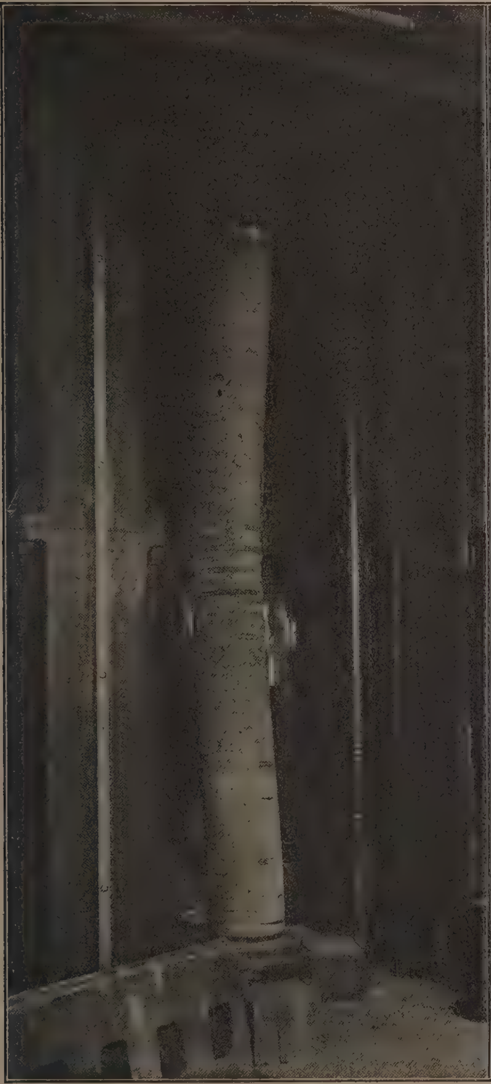


Fig. 6. Hooped Column.

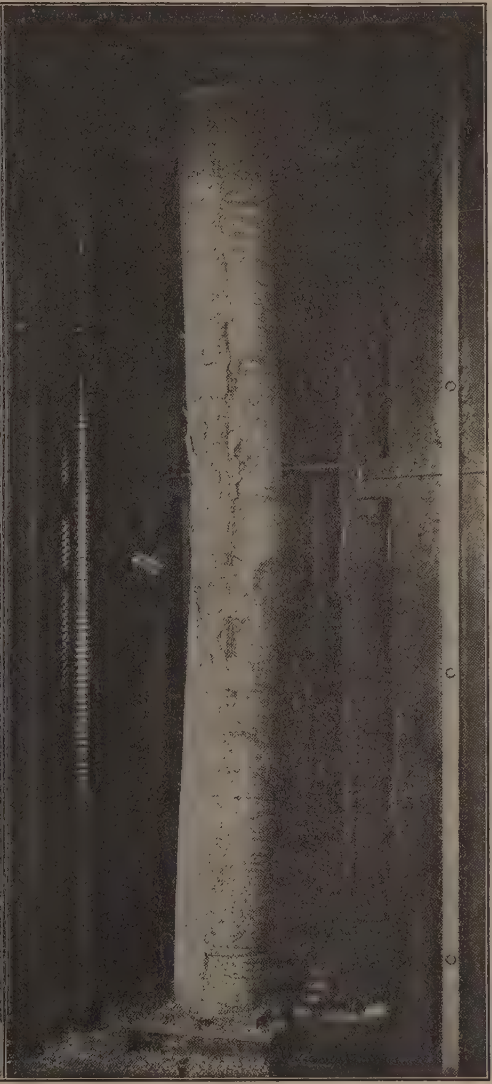


Fig. 8. Helical-Wound Column.

An experiment of some interest was made by first loading a hooped column and then stripping the wire from it and testing the naked column. This column was loaded to 2000 lb. per square inch, and showed a unit shortening of 0.0036. The load was released and a set of 0.0025 was found. A load of 2000 lb. per square inch was again applied (the unit-shortening becoming 0.0041) and then released. The spiral was then stripped from the column without taking it from the machine and the naked column failed at 1080 lb. per square inch. As the indications of the stress-deformation diagram are that the plain concrete would have held 1200 lb. per square inch. on the first application of the load it may be considered that the concrete sustained 90 per cent. of its original strength. The hooped column itself might have held 2200 or 2400 lb. per square inch. A test was made with a column eccentrically loaded. It was found that the hooped column acted as would be expected of a homogeneous column under the same conditions. This may have a bearing upon the explanation of the action of such columns. An analysis based on hydrostatic pressure would require that the internal pressure be distributed uniformly over the column, and hence only concentric loading would be allowable.

The writer feels that there is much yet to be learned about hooped concrete, and he has already had to give up several preconceived notions of the action of restrained concrete. As experimental work which helps to clear up uncertainties may be of advantage to the engineering public, the writer presents this matter without waiting for a complete study of the data, and gives the following tentatively as observations on these tests.

1. Poisson's ratio for concrete in compression is a variable quantity, increasing considerably just before the ultimate failure of the concrete. A value of 0.1, or somewhat more, may be tentatively given for the lower loads, and 0.25 to 0.3 near the crushing load. This concrete set in air.

2. In hooped columns the hoops do not come into action to any great extent before a load equivalent to the ultimate strength of plain concrete, or a little below, is reached. The longitudinal deformation and lateral deformation of the concrete are not modified by the hooping to any great extent before this load is reached.

3. Beyond this point both the longitudinal deformation and the lateral deformation are approximately proportional to the added load. The ratio of lateral to longitudinal deformation is more nearly constant, and in these experiments the ultimate strength of the column is controlled by the elastic limit of the hooping.

4. The total amount of shortening before failure occurred was very great, averaging something like 8 or 10 times that for plain concrete columns, and 60 times that at the ordinary working stress in plain concrete. The longitudinal shortening is, say, 8 times that of mild steel at its elastic limit. Cracking and peeling of the concrete appear at loads corresponding to the ordinary ultimate strength of concrete.

5. The excessive amount of shortening before failure affects the problem of combining hooping and longitudinal reinforcement very unfavorably, if the stresses are to be kept within the elastic limit of the latter.

6. The lateral deflection of hooped columns is large and may affect the ultimate strength which is available for the column. For continued application of stress beyond the maximum load, the column deflects enormously. Scaling of surface of concrete and lateral deflections are warning signs given well before danger of failure exists.

7. The concrete itself retains a considerable element of its strength even after it has shortened in a hooped state four or five times as much as would produce failure in unhooped concrete columns.

8. Columns of richer and leaner concrete exhibited phenomena of similar characteristics, the hoop stress becoming effective at the ultimate strength of unhooped concrete.

9. Hoops of high elastic limit steel give greater strength than of mild steel, but the increased amount of shortening necessary to develop the full strength of the column is an undesirable feature.

10. One experiment indicates that hooped columns will resist eccentric stresses in somewhat the same way as will other material.

11. Light hooping offers security against sudden failures and unevenness of concretes, and will enable higher working stresses to be used. In combination with rich concretes and longitudinal reinforcement, using low stresses in the hoops, i. e., basing the strength upon an assumed ultimate strength but little beyond the average ultimate strength of plain concrete) a satisfactory column may be made. It is suggested that a column of this character may be designed in such a way that the longitudinal reinforcement may carry the load during construction and still not be overstressed later for the additional stress which goes with the concrete, provided the basal point for the column strength is somewhat below the ultimate strength for plain concrete.

12. Heavy hooping gives added strength, but in utilizing the full strength of such columns the column shortens unduly, deflects laterally, and will strain longitudinal reinforcement many times beyond the deformation which exists at the elastic limit of the metal. It may be applicable where a large limit of safety is desired, or where large variations in shortening are unobjectionable, as where the structure is articulated. So far as ultimate strength is concerned, hooping adds two to four times as much strength to the column as does an equal amount of longitudinal reinforcement.

A HEAVY RAINFALL, 1.85 in. in 25 min. and 2.78 in. in an hour occurred in Baltimore on July 18. On July 12, 1903, 2.78 in. fell in 35 min., the record precipitation for the city. The heaviest storms recorded in the United States are 11.5 in. at Campo, Cal., in one hour; 8.8 in. in one hour at Palmetto, Nev., and 6.9 in. in 55 min. at Tridelphia, W. Va.

The Fall of an Arch of the Berlin City Railway.

The accident to an arch of the Berlin City Railway described in the following notes is considered by "Beton und Eisen," from which the information is taken, as a complete proof of the unreliability of the tensile strength of masonry, for the high character of the construction of this viaduct is well known. The fallen arch differs from the others only in the fact that the latter have the rough brickwork exposed. Owing to its location it was considerably ornamented, as were a few other spans adjoining it. The fallen portion shows an interesting view of the structural character of the arch. The brickwork of the latter is about 2 ft. thick and below it a large hollow space exists, the lower side of which was formed by the ornamental work, which did not have the same shape as the main arch. In order to give it the necessary support a wire cloth with coarse mesh was employed. The space between the brickwork and the ornamental surface amounted in some places to as much as a couple of yards. The piece that fell from the arch came from the neighborhood of the abutment and in falling bodly injured the decorative arch below. It was a triangular mass of masonry weighing about 3 tons, the sides measuring from 6 to 10 ft. The smooth bed of concrete over the masonry shows a yawning diagonal crack, opening as much as 6 in. at the widest point, which apparently existed for considerable time. Below it the masonry was smeared with oil and tar, which apparently had gradually worked down for a long time from the ballast above. It is considered possible that eventually water and oil forced their way down into the pores of the masonry and that the adhesion of the joints was thus gradually destroyed.

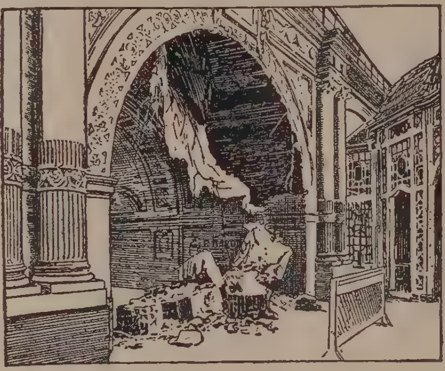
Opinions concerning the cause of the accident are very divided. It is reported that an investigating committee found that one of the foundations had sunk about 1¼ in. In other quarters it is believed that in consequence of the continued vibration due to the passing trains cracks were caused in the masonry which were not observed on account of the decorations hiding them from the eye. Part of the damage has also been attributed to the very severe winter. The moisture entering into small cracks of the main arch might have been frozen on account of the severe cold and thereby caused heavy stresses.

It is not to be overlooked, according to the journal from which these notes are taken, that the falling of so large a block of masonry would not have been possible had the disturbing forces not been great enough to overcome the shearing strength of the masonry and the friction due to the horizontal pressures. Nevertheless it is possible that the assumptions made in the course of the computations of the arch may not have been entirely fulfilled by the actual construction, and that during the setting of the masonry a part of the arch became pressed together very little or not at all, since in this work there was no provision made for a general uniform division of the loading over the individual arches. Under such conditions, if a few cracks destroying the shearing resistance arose, they would be sufficient to allow the mass thus separated to fall.

An Improved Arrangement of Service pipes has recently been adopted by Mr. Frank E. Merrill, water commissioner of Somerville, Mass. Instead of laying numerous small pipes across the street, one for each house, the method is now employed of laying one pipe 1½ in. in diameter from the street main to the sidewalk, and then extending smaller branches from this service pipe up and down the sidewalk to the various houses. Where the conditions are favorable a brick chamber is constructed in the sidewalk so that the main service gate and all the branch gates and connections can be reached.

Dust Prevention in the Boston District.

Dust prevention and road destruction in and about Boston have been receiving the attention of the Massachusetts Highway Commission, the Metropolitan Park Commission and the Boston Park Commission, and so many experiments are being made on a large scale that before long it is reasonable to expect some valuable information will be obtained. The work is particularly interesting on account of the extensive use of automobiles in the Boston district, and the consequent destructive travel on most of the good roads in that vicinity. One of the most thorough tests is being made by the Metropolitan Park Commission on the Revere Beach Parkway. A portion of this well-known roadway was treated with tarvia last year and another portion has been similarly treated this year. The procession of motor cars along this parkway is a close one at certain times of every pleasant day, and the effect of the treatment in preventing dust and the destruction of the road is consequently being determined with unusual thoroughness. In places the roadway which was treated last year has gone to pieces, raveling out somewhat like an ordinary broken-stone road in very dry and windy weather; the surface shows a considerable quantity of loosened stones, but even there the road is practically dustless. The latter condition has been obtained without any watering, which shows the value of such applications in preventing dust, and indicates that while the first cost of an application may be large, the saving due to the omission of watering may largely counterbalance the expense of applying the tarvia.



Damaged Arch at Berlin.

It is believed that these badly worn places are due to the effect of the heavy motor car travel, but there are other places where holes occur which are believed to be due to the presence of too much clay or loam in the binding material used in making the road or to the application of the tarvia when the roadbed contained considerable moisture. In this connection it might be stated that there is a marked difference between the methods of applying tar preparations in the vicinity of Boston and the methods which are considered most satisfactory in France. In France never more than a thin coat of grit, amounting to little more than a mere sprinkling, is applied to the treated roadway, while about Boston a heavy coat of screenings seems to be considered necessary. This and some other differences in methods result in an average cost of about 12 cents per square yard for tarring some of the Massachusetts roads as compared with about 3 cents in France.

While tarvia has been used extensively, other preparations are being employed and some of them have already had considerable use. An experience with one of these, a preparation of Kentucky oil, in which some asphalt is dissolved at Revere Beach indicates that where the surroundings of the road have to be kept as clean as practicable, it is necessary to take special precautions to prevent their staining from the spreading of the preparation beyond the surfaces to which it is applied. In this particular case concrete gutters had been constructed and great care was taken to prevent the liquid from reaching them. This liquid leaves the roadway almost black, and an attempt was consequently made to keep any of it from the light gray gutters. This was successfully done while the material was being applied, but during the night following its application a rain occurred which washed some of it into the gutters, which were badly stained in consequence, thereby injuring one of the particularly attractive features of the roadway. An attempt will be made to restore the appearance of these gutters by cleaning. Another interesting experiment with this preparation of Kentucky oil and asphalt is being made by the Metropolitan Park Commission in Watertown, where a long stretch of gravel road is being treated with it. If a gravel road can be made more durable and its dust reduced by such an application, the result will be decidedly important, particularly in those districts where good road gravel is abundant and broken stone is costly.

The State Highway Commission is proceeding in a conservative way to test the various methods of reducing the wear on roads, and expects to spend about $20,000 this year in the work. For the present its experiments are confined to the use of tarvia, as it seems to give a more durable surface than other preparations which the Commission has observed in service; while the latter may be successful in laying dust, the Commission desires to obtain some material which will actually improve the surface of the road or at least reduce the rate of its deterioration. An interesting fact which has been brought out by the experience to date is that the application of preventatives of dust and wear to a new road is of little value. The surface of the new road is open and until it has been subjected to enough traffic to become consolidated and to permit the cementing action of the materials to form a compact mass, the application of tarvia and other preparations seems to be of little use.

Right-of-Way Areas.

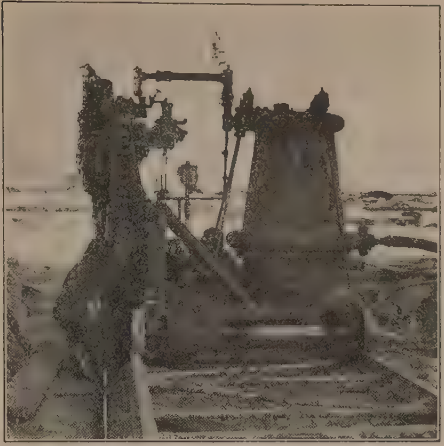
Rights-of-way of various widths are readily reduced to acreages by means of the following table, compiled for use by the engineers of the Western Pacific Railway Co. The acreages are for rights-of-way 100 ft. long and of the widths respectively stated; thus: a right of way 100 ft. wide and 1 mile long contains 1.21 acres (0.229568 × 52.8 ≐ 1.21+.) Logarithms of the respective areas as well as the acreage of 1 square foot and its logarithm are also given. Areas may be readily figured by the use of the slide rule in conjunction with the table:

Right of Way Width.	Area in Acres.	Logarithm.
10 feet	.022957	8.3609113
50	.114784	9.0598813
60	.137741	9.1390633
100	.229568	9.3609113
120	.275482	9.4400932
148.5	.340908	9.5326371
150	.344352	9.5370026
180	.413222	9.6161834
200	.459136	9.6619413
1 sq. ft. =	0.0000229568	—5.3609113

A Vitrified Clay Water Main 12 in. in diameter and 3 miles long has been constructed at Hobart, Okla., under the direction of the U. S. Geological Survey. It is made of double-strength pipe and is subjected to a maximum head of 14 lb. The joints were calked with oakum and run with a mixture of both pure and crude asphalt and petroleum.

The West Neebish Channel of the St. Mary's River.—II.

Rock Excavating and Handling.—The depth of the rock cutting varies from nothing at each end of the 8,600-ft. cut to as much as 27 ft. at the middle of the latter, with an average depth of 15 to 16 ft. The rock has mostly all been taken out in two lifts, the faces being worked the full width of the cut. Four steam shovels and four cableways have been used, one shovel to each cableway. Generally, the shovels have been worked in pairs, one shovel removing the top lift, and being followed by the other working on the second lift. The work has been handled in two lifts in this manner, in order that the sides of the cut could be made vertical with channeling machines. Four of these machines have been used, two Sullivan and two Ingersoll-Sergeant, all of which are capable of cutting to a depth of 14 ft. The specification provided payment for the removal of the sides of the excavation to a slope of 1 on 1, but stipulated that the contractor would be paid for all excavation out to these slopes, if the sides of the cut were channeled, which has been done accordingly.



One of the Channelers.

General View of River Improvement at Rock Section.

The holes for the blasts necessary to break up the hard rock are made with 3¼-in. Rand drills, 30 of which are installed. The holes are made in two or three rows, depending on the character of the rock and other circumstances. Owing to the nature of the rock, the blast holes have to be placed at the four corners of 4 x 6-ft. or 5 x 5-ft. squares, making the cost of blasting very high. Half of the face of the cut is shot at a time, in order that the drills may be working on one half while the shovel is removing the muck from the other half. Dynamite is used for blasting, which is done almost entirely in the daytime.

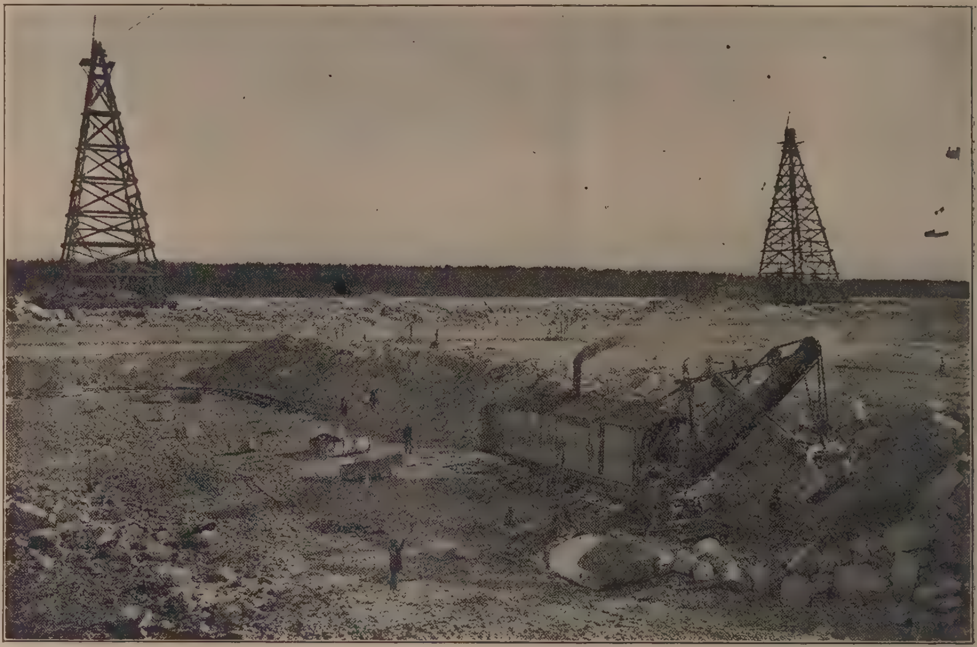
The four steam shovels used in loading the loosened rock into the cableway skips are specially adapted to working in the cut. They are Model 60 Marion shovels, each with a 26-ft. boom carrying a 2½-yd. bucket. Each shovel is equipped with a traction gear which is capable of propelling it on wheels with 30-in. tires, without track, the same as the Model 20 shovel made by the same company is propelled. The driving gear is attached to the front wheels, the 10-in. steel axle of which is fixed, the steering being done with the hind wheels, which are on a pivoted axle. The shovels move on the rock bottom of the cut back and forth along the face without difficulty and can make a complete turn to start work in the opposite direction in 15 to 18 minutes. At rare intervals the shovels become stalled on rough bottom, or toward the ends of the cut where the rock runs out. The fall blocks of the cableway serving the shovel are then fastened to the front or the rear end of the latter, which can thus be helped along over the bad spot without any trouble.

Part of the Heavy Walls along a Portion of the Channel.

The boilers of the shovels are all supplied with water from a pump in the plant midway on the cut which houses the boilers supplying steam to the 8-in. and 12-in. reciprocating pumps in that plant. A 2-in. exposed pipe line, extending to both ends of the work from this plant has been able to supply water to the shovels and to hoisting engines for the derricks that are installed during the coldest weather by a method of operation which has been developed since the work was started. A 5,000-gal. circular wooden tank is placed in the boiler room of the plant and is heated during cold weather by the exhaust steam from the 8-in. and 12-in. pumps. Either of the two pumps on the supply line to the shovels and derricks draws from this tank, the steam exhaust of the pump in service being turned into the suction pipe of its water end. The temperature of the water is thus raised to about 100° Fahr., by the exhaust from the three pumps, so it does not fall below the freezing point before reaching the shovels and derricks even during the most extreme weather, due to a method of operation that has been adopted. When a shovel engineer needs water he can ring an electric signal bell in the pump house. The pump is then started and run until the engineer signals again, when it is shut down. The water left in the pipe leading to the shovel is then immediately blown out under a pressure of 90 lb., with air from the compressor supply line, and the pipe closed until water is required again. Arrangements were made to use steam to thaw the pipes after the water has been drawn from them, but the steam has never been necessary, as the distributing pipes are free from ice at all times.

An interesting condition developed in connection with the operation of the air line used to blow out these 2-in. water supply pipes. Shortly after the 2-in. air line for blowing the water pipes was installed it became difficult to maintain the usual pressure in the main air lines. Investigations determined that, on the average, the 2-in. water supply pipes required air about 7 hr. out of the 24 hr., so a large amount of air was thus consumed. A plate with a ¼-in. circular hole was then placed in the 2-in. air supply line to the pump, in order that no air might be wasted. The result was that the pressure in the main air lines was at once restored, although the water could be blown out of the supply line as efficiently as before.

The four cableways are worked in two pairs, one pair operating from a point near the middle of the cut to the downstream end of the latter, and the other pair from the middle to the upstream end. The specifications were written with the idea that the channel may eventually be widened on the east, or island side. Accordingly, the material from the excavation can be dumped in the river adjacent to the improved channel, so long as the spoil banks within 300 ft. of the east side of the latter are not higher than the top of the retaining wall along that side of the cut. On the west side of the channel, the spoil banks are permitted to come within 50 ft. of the cut and the space between them and the latter can be filled to the level of the top of the wall. Owing to the nature of the river bed and bank on the west side of the cut for about 3,600 ft. from the upstream cofferdam, head towers for traveling cableways could not be operated with any degree of safety or satisfaction. The ground on the island side of the upper end of channel was satisfactory for the operation of the head tower, however, so cableways long enough to span the 300-ft. channel cut, the 300-ft. berm along the latter and sufficient space for spoil banks between the edge of this berm and the head towers had to be installed. At the downstream end of the channel conditions were much more favorable for the operation of head towers on the mainland side of the river, permitting shorter-span cableways to be installed.



Steam Shovel Loading Cableway Skip.

One of the Cableways and Its Spoil Bank.

The four cableways were made by the Lidgerwood Mfg. Co.; the two upstream ones have spans of 1,100 ft. each and the two downstream ones, spans of 800 ft. each. The capacity of the cableways is probably best illustrated by the loads which they have carried regularly in service. The stone which is being removed from the cut is very dense, weighing about 4,600 lb. to the yard; pieces of this stone containing 6 to 8 cu. yd. have been lifted out of the excavation, however, and conveyed to the spoil banks without any apparent difficulty. The head and tail towers are all mounted on trucks traveling on rails parallel with the cut. These towers have a clear height of 103 ft. above the base of rail, each pair of towers containing 85,000 ft., board measure, of timber. The front end of each tower of the 1,100-ft. span cableways is carried by seven pairs of wheels, three pair in a group under each corner and one pair on the center line. Seven more pair of wheels are placed under the rear legs of the tower and are spaced the same as those at the front end of the latter. Three lines of rails laid under the counterweight end of the tower platform carry eight pairs of wheels, staggered alternately so each outer rail of the three carries four wheels and the middle one eight. As compared with the usual arrangement of wheels for a cableway tower, in this case an extra pair is added under each leg of the tower and a pair under the middle of each side of the tower platform. The great load on the wheels and rails is thus distributed in such a way that bending of the rails is prevented. The tracks can therefore be kept up and the towers can be moved much more easily than if fewer wheels had been used. The towers for the 800-ft. span cableways are the same as those just described except they have five pairs of wheels in a row where the others have seven. A 50-h.-p. moving engine is provided on each tower.

Each cableway is operated by a double 12¼ x 15-in. engine driving a 59-in. hoisting drum, all in a house on the head tower. This engine gives the carriage a hoisting speed of 250 ft. and a traveling speed of 1,200 ft. a minute. The section of the hoisting drums carrying the endless cable line is covered in each case with a rim of boiler plate steel which wears much better than the regular material in the drum and can be replaced readily when worn. The carriage of each cable is equipped with an extra block, and an increased diameter section is added to the hoisting drum of the engine, so the skips can be dumped in the air by the hoisting engineer. This aerial dumping device was invented by Mr. Locher during the progress of the work on the Chicago Drainage Canal, and is the one which has been in general use since then.

A 2¼-in. lock-bar cable, made by the Trenton Iron Works, is used on the main cable in each machine. The repairs to the lock-bar cables have been very much simplified since the inception of the work, until now all minor repairs and some rather extensive ones are made without lowering the cable. When a strand breaks the ends at the break are lapped about ½ in. and are filed down on a bevel to form a flat joint, as nearly as possible. This is wrapped with fine brass wire, then covered with a little borax and heated to the welding point with a blow torch. The brazed joint is then filed down to the same cross section as the remainder of the strand, in order that the latter may be driven back into place. In case the ends at a break are not long enough to lap, a piece is cut out of the strand and another piece long enough to lap is welded in its place. Small steel clamps with tightening screws are placed around the cable to hold the loosened strands in position while the repairs are being made and to assist in replacing the mended strands.

The repairs to the cables and cableway carriages are greatly facilitated by small cabins erected over the ends of the cables at the head towers. During the extremely low temperatures which occur in the winter it would be practically impossible to make repairs on these towers, 100 ft. or more above the ground without some such protection, and even with the latter men are often frost-bitten.

The skips used in connection with the cableways have a capacity of 6 cu. yd. each. They are built of heavy steel plates, but the extremely hard rock which is handled into them with the steam shovels breaks and bends them very quickly, 35 of these skips having been used in this work.

Retaining walls varying from 5 to 20 ft. in height and having a minimum top width of 5 ft., are built along both sides of the channel for a length of 5,000 ft. The tops of the walls are 6 ft. above extreme low water, the walls being built as a guide to traffic. They have been built of large stones taken from the cut, many of these stones containing 2 to 6 cu. yd. The limestone through which the channel cut is being made is quite evenly stratified and breaks out in regularly shaped pieces. At points where the stone occurred in particularly uniform strata, areas were reserved from the general excavation in order that the rock might be quarried carefully out of these areas for use in the walls. Four stiff-leg derricks operated by steam-driven hoisting engines, are used in handling the stone in these small quarries and in building the wall. With the exception of these four hoisting engines, the steam shovels and three pumping plants, all of the equipment on the work is operated on air from the central compressor plant.

Sixty-five Ton Shovel and Six-Yard Skips.

The work within the cofferdams is now rapidly approaching completion. The rock cut is finished up to within a short distance from each end, the excavation having been carried to and below the required grade, and the bottom finished as the work progressed. The excavation had to be carried below the grade in places in this manner in order that the steam shovels could follow the plane of the inclined strata which occur in the rock. The retaining walls along this cut are practically done. A small amount of earth excavation between each end of the rock cut and the main cofferdam will be taken out with the steam shovels and conveyed to the spoil banks by the cableways. When this is finished and the work has been cleaned up it is planned to admit the water into the area enclosed by the cofferdams very slowly to prevent any of the loose material being washed into the channel. The portion of the cofferdams across the channel and the small portion of the channel in earth between the ends of the rock cut and the cofferdams will then be removed with a dredge.

The progress that has been made in executing this work is well worthy of notice. As has been mentioned the first work was started early in the summer of 1904, but it was early in the summer of 1905 before the whole area enclosed by the cofferdams was unwatered. Therefore, practically all of the work will be done in two and one-half years; at the same time, it should be borne in mind that the time limit on the work does not expire until Aug. 18, 1908, or in other words, the contract will be completed nearly a year ahead of time.

The quantities of materials handled by the plant installed also merit attention. During the month of June, last, the four cableways and four steam shovels handled approximately 86,000 cu. yd. of rock, or an average of 21,500 cu. yd. to each shovel and cableway. The output for July will be approximately the same amount. The monthly output since the four shovels and four cableways have been installed has ranged in the neighborhood of 65,000 cu. yd. In this connection it is interesting to observe that the ouput of the cableways used most sucessfully in rock cuts on the Chicago Drainage Canal ranged in the vicinity of 8,000 cu. yd. a month when operated an eleven-hour day shift. At the same time, the rock in that work was much more easily blasted and was not so hard on plant as is the rock which has been encountered in this contract.

Another significant feature of the operations on this work is that the number of skips of stone handled at night by the cableways is about the same as the number handled in the day time. This condition may probably be attributed to two principal causes, the lighting and the efficient method of inspection and repairs which is followed. The method of inspection and repairs is also largely responsible for the maintenance of operations so successfully during the winter.

The lighting in the field is done with portable Kitson gasoline lamps, enough of which are used so all operations can be carried on without interference. The blasting is practically all done during the day, but when any blasting has to be done at night the lamps can very readily be moved out of range.

The method of inspection and repairs that is followed is very thorough. In the first place, the whole work is so far isolated from a base of supplies that a very large amount of extra parts and materials for repairs are kept on hand constantly. For instance, an extra steam shovel dipper, a dipper arm, one of the heavy traction gears and shaft, and so forth, are always ready for use. The small parts of the various machines are also kept in quantities in a supply house, the total quantity of extras and repairs on hand representing about $20,000. The parts of each machine which are most liable to need replacing, such as the cableway sheave wheels and the like, are kept at the machine in order to save the delay necessary to bring extras from the supply house. A blacksmith and machine shop in which most repairs can be made is also provided. The second feature of this maintenance system is the inspection method followed. A mechanic and helper are placed in charge of each two cableways, the carriages of which are carefully inspected at meal hours, or at other times when they are brought to the head towers. Any necessary repairs are made then, if possible, but if it is impracticable, they are delayed until a more favorable time. The steam shovels are also under the constant supervision of a mechanic, whose sole duty is to go over the shovels daily in an endeavor to find any defective parts. That this unusually close system of inspection has proved profitable, is evident from the rapid progress which has been made.

The supplies for the three camps which the contractor built and maintained on the mainland at the work are brought from Sault Ste. Marie by boat during the open navigation season, and over land in sleighs the balance of the year. Coal to operate the various plants and for the camps is delivered entirely by boat, enough being brought in each summer to last through the winter. Thus far, in the neighborhood of 40,000 tons of coal has been used. The majority of this has been required in the compressor plant. A road was built through the dense timber along the river by the contractor and such coal as is used at points where delivery is not made by boat is hauled along this road in wagons.

The improvement of the West Neebish Channel is being carried on under the direction of Col. Chas. E. L. B. Davis, Corps of Engineers, U. S. A. Mr. L. C. Sabin is assistant engineer, Corps of Engineers, U. S. A., with headquarters at Sault Ste. Marie, Mich., and has charge of all construction and administration of the nagivation in the St. Mary's River. Mr. Sutton Van Pelt is in immediate charge of the work under Mr. Sabin. Mr. A. S. Robinson is local manager of the Sault Ste, Marie office of the MacArthur Bros. Co.

The New Warehouse of the Newark Warehouse Company.

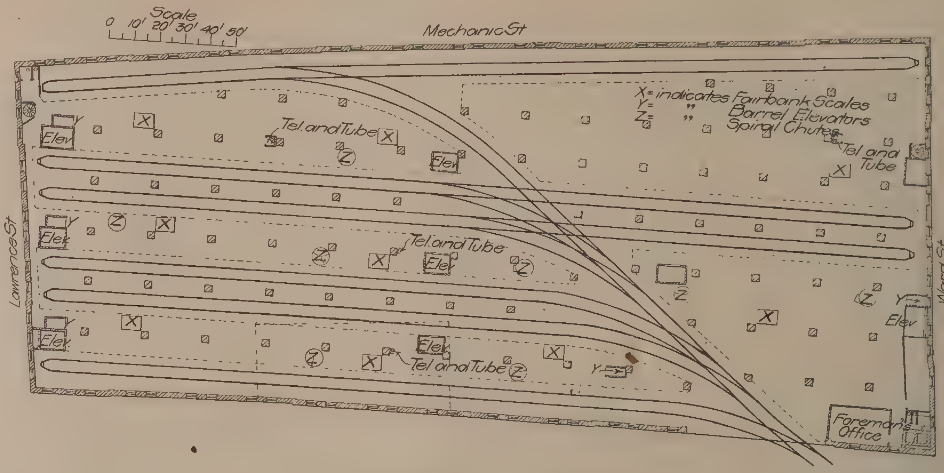
The Newark Warehouse Co. has just completed a large 6-story fireproof building in Newark, N. J., which presents some interesting features of warehouse design, many of them due to the peculiar local conditions in Newark. The building will be used by the Central R. R. of N. J. to accommodate its local freight business and this fact combined with the scarcity of available property and the elevation of the tracks of the railroad through the city caused the adoption of a design differing widely from those customary for terminal facilities. At the same time the building offers a safe and convenient storage for freight which is not taken promptly by the consignee and thus allows the release of cars and their prompt return to service. The building, therefore, combines the facilities of a freight delivery and receiving terminal and of a general storage warehouse.

These facts made the method of managing the building an important consideration which was finally worked out so that the entire structure with its contents is under the control of the warehouse company. The tariff covering the storage charges varies according to the class of merchandise and is double the rate for the first month, and single rate thereafter, the double charge covering the cost of handling the freight to and from storage. The question of insuring a building of this character together with its valuable contents is also a matter which received careful consideration. The building was constructed and equipped with fire protection apparatus to meet the requirements of the Associated Mutual Fire Insurance Companies with the result that they have written the insurance not only on the building but have taken a blanket policy on its contents.

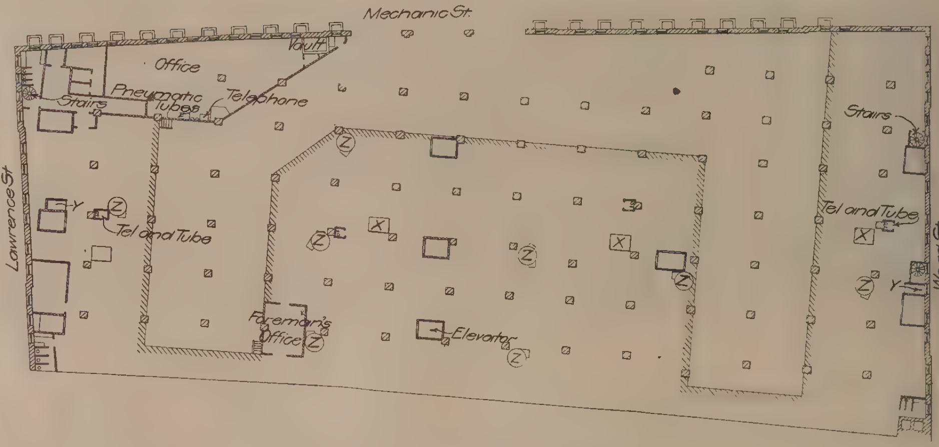
The building is situated on Mechanic St., between Ward and Lawrence Sts., extending back to the property of the Central R. R. of N. J. It is 360 ft. long with a width varying from 130 ft. on Lawrence St., to 165 ft. on Ward St., and has a storage capacity of about 1,200 carloads of freight. It is a steel frame structure with reinforced concrete walls and floors, containing 7 floors in all, the first devoted to teaming, the second to the freight tracks and the basement and the four top floors to storage. The fact that the tracks of the railroad are elevated through the city made it advisable from the first to unload the cars on the second floor and this immediately required provisions for lowering large quantities of freight to the teaming floor as well as a skillful arrangement of tracks inside the warehouse to allow of the unloading of as many cars as possible at the same time. The transfer of large quantities of freight between the first and second and the storage floors further emphasized the need of rapid and adequate elevator facilities.

The use of the ordinary platform elevator was considered not only expensive but very slow and it was therefore decided to put in spiral conveyors suitable for lowering packages in the form of barrels, boxes or bags of a limited size. These spiral chutes though used to a limited extent in some department stores have not, so far as is known, been applied to the handling of large quantities of miscellaneous freight. They are 8 in number, 5 with single and 3 with double spirals, all made by the Otis Elevator Co. They are constructed of sheet steel enclosed in cylinders 7 ft. in diameter. Three of them extend from the top to the first floor, one from the 6th to the 2nd, two from the 2nd to the basement, five from the 2nd to the 1st floor. The reason for the principal connection between the 1st and 2nd floors is that the majority of freight passing through the warehouse will be direct from the cars to the teams. The conveyor extending from the 6th to the 2nd floor is for freight which may come from the storage floors to be reloaded into cars. The discharge openings of these conveyors are permanently fixed at certain floors but packages can be placed in them at any of the floors which they reach. They are adapted for any packages no matter how small up to a maximum of 36 in. square and 4 ft. long. Their carrying capacity is only limited by the rapidity with which the packages can be put in at the top or taken away at the bottom.

There are 5 electrially-driven barrel elevators installed by the Link Belt Engineering Co., two running from the basement to the top floor and three from the 2nd to the top floor, having carriers about 8 ft. apart attached to an endless chain. They are adapted for either sacks, barrels or boxes and have an almost unlimited capacity, it being possible to raise a carload of flour to any of the floors in half an hour or less. They can be run in either direction, so that the packages can be lowered as well as elevated by them, but the probability is that practically all the freight which they raise will be lowered by the spiral conveyors. Automatic trips are installed at each floor and when once set discharge the elevator without further attention. When the elevators are used for raising packages, special arms are attached to the frames of the elevator shafts and on these arms are placed the packages to be carried up by the elevator. The carriers come up between these arms and pick up the packages. In case the elevators are used for lowering freight the packages are placed on the carriers by hand and caught by the arms just referred to on the floors where they are to be discharged. Special skids or platforms are used to aid the safe delivery from the elevators. The nine platform freight elevators are of the direct-connected electric type made by the A. B. See Electric Elevator Co., and have a carrying capacity of 6,000 lb., with platforms either 7 x 10 ft., or 8 x 12 ft. in size. One elevator runs from the 1st to the top floor, two from the 1st to the 2nd floor and the other 6 from the basement to the top floor. They will be used for large packages which cannot be handled by the barrel elevators or the spiral conveyors.



Plan of Second or Track Floor.



Plan of First or Teaming Floor.

The design of the 2nd floor of the building influenced to a large extent the arrangement of the other floors. As seen by the accompanying sketch the cars are brought inside the building and unloaded from 6 parallel tracks to platforms which are raised to the level of the car floor. The ends of the tracks toward Lawrence St., are intended particularly for inbound freight and at the Ward St. end for outbound freight, which may be reloaded in the cars from the different storage floors. The cars on the tracks at the Lawrence St. end of the building can be handled by a switch engine, but those placed on the tracks toward Ward St. will be handled by ropes running to an electrically-driven capstan. The capacity of all the tracks is about 45 cars.

The location of the elevators and spiral chutes was arranged so as to afford the greatest facility for handling the freight as it came from the cars, whether intended for immediate delivery to the teams on the first floor or for storage in the rooms above. The platforms on both the first and second floors are provided with Fairbanks automatic scales, nine on the second, and four on the first floor to afford a convenient means for weighing the freight.

The first floor is devoted to the delivery of freight to teams, and to the main office which is located at the corner of Mechanic and Lawrence Sts. The large platform in the center is intended for freight coming direct from the cars and the two end platforms for the freight coming from storage, but in case of emergency either or both of the two end platforms can be used for freight going direct from the cars to the teams.

The entire operation of the warehouse is controlled from the office by a private telephone system with stations on all the platforms of the first and second floors and at the center of the storage floors. The system also connects with the lines of the Central R. R. of N. J., reaching all outlying points in the railroad yards, and with the public telephone system of the city of Newark. On the platforms the telephones are placed in the small offices which have been provided for the clerks looking after the freight. In addition to controlling the operation of the warehouse by means of the private telephone system, there has been installed a pneumatic tube system which affords means of sending orders or receipts from the office to any point in the warehouse. The telephone and the tube systems together will afford a quick and positive means of communication between the office and the various sections of the building and will thus greatly expedite the handling of the business.

New Warehouse of the Newark Warehouse Company.

The pneumatic tube system was installed by the Lamson Consolidated Store Service Co.

The basement is divided into 13 sections, 10 of which are devoted to storage and are intended for such stocks as it is desired to keep cool and in a uniform temperature. One of the remaining sections contains a reservoir for supplying the fire pumps and the other the engine and boiler room. The latter contains a heating boiler for warming certain sections of the building and a reserve space wherein can be placed a turbine generator if it is ever desired to make the building independent of outside sources for electric current. A twin stack has been put in the building so that a ventilating equipment can be installed in the basement should that ever become necessary, one of the flues being reserved for this purpose. The fire pumps and air compressors are also located in this section of the building.

The third, fourth, fifth and sixth stories are divided transversely into 5 large storage compartments reached by 7 platform and 5 barrel elevators and 3 spiral chutes. In addition, at each end of the storage floors, there is a large open space around the elevators which can be used temporarily for freight that has not been allotted regular storage space. The floors are divided into about 100 sections each, by having numbers painted on the beams overhead to indicate the sections, these divisions permitting a record to be kept of the definite location of any merchandise which may be stored in the building. The carrying capacity of each floor is also plainly marked at each section. The elevators and chutes are lettered and numbered and at each opening of the spiral conveyors the floor at which the packages will be discharged is shown by a number.

The partitions between the compartments are of hollow tile double-celled blocks 8 in. thick, and the stairways and elevator shafts are enclosed with tile blocks 4 in. thick, laid in Portland cement mortar. The doors between the compartments are standard tin-covered fire doors, made of 3 thicknesses of 1-in. white pine boards, hung on an inclined rail, with a standard automatic fusible fastening allowing the door to close in case of fire. Similar doors are used for the barrel elevators and stairways. The doors for the platform elevators were made by the Automatic Door and Gate Co., and are self-closing whenever the elevator leaves the floor and can be opened only from the elevator side except on the first story. The windows have metal frames and sash, glazed with wire glass, with an automatic fusible attachment making them self-closing in case of fire.

The building is equipped throughout with the dry system of sprinklers installed by the General Fire Extinguisher Co. In this system numerous air valves throughout the lower stories of the building cut off the water from the sprinkler heads, thus leaving the pipes and headers charged with air, which is released by fire, acting on the sprinkler heads, permitting the discharge of water from the heads. The system can be supplied from three independent sources, thus guaranteeing against failure of any one or two of the supplies. Water can be obtained from the high pressure service of the city of Newark, maintaining a pressure of 140 lb. to the square inch, from two hemispherical-bottom tanks, furnished by the Chicago Bridge and Iron Works, of 30,000 gal. capacity each, carried 25 ft. above the roof of the building, or from two 750-gal.-per-minute electrically-driven centrifugal pumps drawing on a 150,000-gal. reservoir in the basement of the building. The pumps were furnished by the Fales & Jenks Co., Pawtucket, R. I., and were designed to meet the requirements of the Mutual Insurance Companies. The three independent water supplies are connected to a header located near the pumps on the Ward St. side of the building and by a system of valves any of the sources can be used at will. There are also stand pipes on each floor, with connections for 2½ in. hose, which can be used in case of necessity, but the main reliance is upon the automatic action of the sprinkler system. The power for operating the fire pumps as well as for the elevators and lighting is supplied by the Public Service Corporation and is distributed from a switchboard located in the engine room.

Except for the office on the first floor, the toilet and air valve rooms, and a 60 x 75-ft. section on each of the four upper floors, the building will not be heated.

The building is equipped with the Eco-Magneto clock system with stations at different points to insure the proper patrol by the watchman, and fire-alarm stations connected with the headquarters of the Newark fire department will also be installed throughout the building. These excellent fire protective measures have resulted in insuring the building and its contents at a very low premium with the Mutual Companies.

Construction.—On the south side of the warehouse is the freight yard of the Central R. R. of N. J., elevated above the street about 25 ft. at Ward St., and about 12 ft. at Lawrence St., the embankment being held up by a retaining wall running the entire length of the building. This wall had to be underpinned for a depth varying from 12 ft. at the low end to 25 ft. at the high end before the excavation of the building could be started. The material used for underpinning was concrete put in in short sections, thus avoiding any shoring or bracing. It had to be done with great care as the tracks next to the wall were constantly in use.

The retaining wall was utilized as a foundation for the enclosing walls of the building above the second story, but not for the support of the steel structure, the foundations for the columns being entirely independent of the retaining wall. The latter had a considerable batter which necessitated cutting chases into the wall so as to set the outside columns out far enough to permit the enclosing walls to rest on top of the retaining walls. The cutting of these chases was slow and expensive and after various methods had been tried it was found that the most efficient was by the use of air drills. The chases varied from about 3 ft. deep at the bottom to nothing at the top.

Borings made at the site showed that the natural ground was sand with slight indications of quick-sand. The spread of the grillage beams as at first planned allowed for a load of 4 tons per square foot on the soil and to avoid any risk of settlement the foundations were made a continuous plate of reinforced concrete extending the entire area of the building, and projecting from 6 to 8 ft. beyond the center lines of the outside columns. This plate was 15 in. thick, made with Vulcanite Portland cement, reinforced with extra heavy expanded metal and on it was placed the grillage beams carrying the cast-steel pedestals of the columns. Both the grillage beams and the pedestals were enclosed in concrete.

The steel work of the building carries the entire live load and is unusually heavy. The floor of the second story, which carries the tracks, was designed under the specifications for railroad bridges of the Central R. R. of N. J., taking as the load the heaviest type of switch engine, the remainder of the track being filled with cars having a capacity of 80,000 lb. each. In addition the usual live and dead loads are allowed for on the platforms adjacent to the tracks. The lay-out of this floor compelled the omission of certain columns above the first story and the span of the track entrance doors necessitated unusually heavy girders. The steel in the structure weighs over 7,000 tons, was furnished by the American Bridge Co., and erected by the Pittsburg Construction Co.

The building was first designed to have the enclosing walls above the street of brick with stone trimmings, but labor conditions arose in Newark which necessitated changing to reinforced concrete. The walls are independent of the steel work and are carried down to the concrete plate for a foundation. They are embellished to an unusual extent for concrete work with rustications, mouldings, dentils, and cornices, which have resulted in giving the building a very finished appearance.

The reinforcement of the walls consists of expanded metal supplied by the Expanded Metal Engineering Co., and of ¾-in. rods laid horizontally about 4 ft. apart, overlapping at the ends, with special reinforcement in front of the columns. The concrete in the walls is very dense and there have been no indications of moisture working through. The concrete was a 1:2:4 mixture, using Cow Bay washed sand and ¾-in. trap rock, mixed with Atlas Portland cement. Particular care was taken in the selection of the sand and stone so as to insure getting perfectly clean and uniform material.

The walls are 20 in. thick to the second story, 16 in. thick to the third story, and 12 in. from there up to the top, the parapet walls above the roof being 3 ft. high. The mouldings forming the horizontal lines, such as belt courses, cornices, were carefully levelled, great pains being taken to secure true lines for the concrete work. The cornice has a projection of about 3 ft. from the face of the walls and required very heavy construction for the support of the forms. After the forms were removed from the walls the latter were refinished by applying a very thin 1:2 mortar so as to thoroughly fill all voids, and then rubbed, leaving no thickness to the finish. This has proved very satisfactory and there is no indication of chipping or flaking and no cracks have developed.

The floors above the basement are of reinforced concrete, 6 in. thick for a live load of 300 lb. to the square foot, and 8 in. thick for a live load of 500 lb. to the square foot, the reinforcement being extra heavy expanded metal. They are made of the same proportions of concrete as the walls and finished with 1 in. of cement mortar applied at the same time that the concrete was laid. The surface has been treated with a special material imported from Germany which has made it hard and durable and done away with the dust which usually arises from cement floors. The roof is a 4-in. concrete slab of the same proportion as the floors, covered with a 5-ply felt and gravel roof. The water caught in the gutters is carried to cast-iron pipes carried inside the building with a steam pipe alongside of them so as to prevent freezing in winter.

On the second floor the rails for the tracks rest directly on the 7/16-in. steel floor plates, which are supported by I-beams about 16 in. apart. The rails are fastened with bolts and clip washers, the hole in the plate being made water-tight by a heavy felt washer. After the rails were laid, the joints in the plates, which in all cases came over the I-beams, were carefully cleaned out and run full of a specially prepared coal tar pitch, and the entire surface of the plates was coated with a prepared asphalt paint, making the floor water-tight. The ends of the tracks are protected by Ellis bumpers. The roadway on the first floor is made of rock asphalt blocks with a special asphalt coating or cushion about ⅜ in. thick, this coating being of such a consistency as to afford a firm footing for the horses. The pavement was laid by the Neuchatel Asphalt Co. An oak wheel guard is laid in front of the platforms, with an oak buffer fastened to the upper edge to protect the latter from the wheels of the wagons backing in. The basement floor rests upon the fill, which was put in over the concrete plate, forming the foundation, after the grillage beams and column bases were set.

The columns throughout the building are encased in stone concrete having a minimum thickness of 3 in. outside the steel work. For a height of 4 ft. above the floor they are protected by a steel plate guard, filled with concrete, with an additional cast-iron wheel guard around columns in the driveway of the first floor.

The concrete for the building was all mixed in two 1-yd. electrically-driven Smith mixers located in the basement of the building. A temporary track was laid on the steel work of the second floor and the crushed stone was brought in on cars and dumped into large bins built on the steel work of the first floor. The sand was delivered by carts on the first floor and dumped into a hopper from which it was elevated by a bucket conveyor to bins adjoining those for the stone. The cement was received in cars brought in on the temporary tracks and lowered by a chute to a storehouse on the first floor. The sand and cement were discharged by gravity into measuring bins and the cement and water were added as the material passed into the mixers. This reduced the labor of handling the material to a minimum.

Track or Second Floor of the Warehouse.

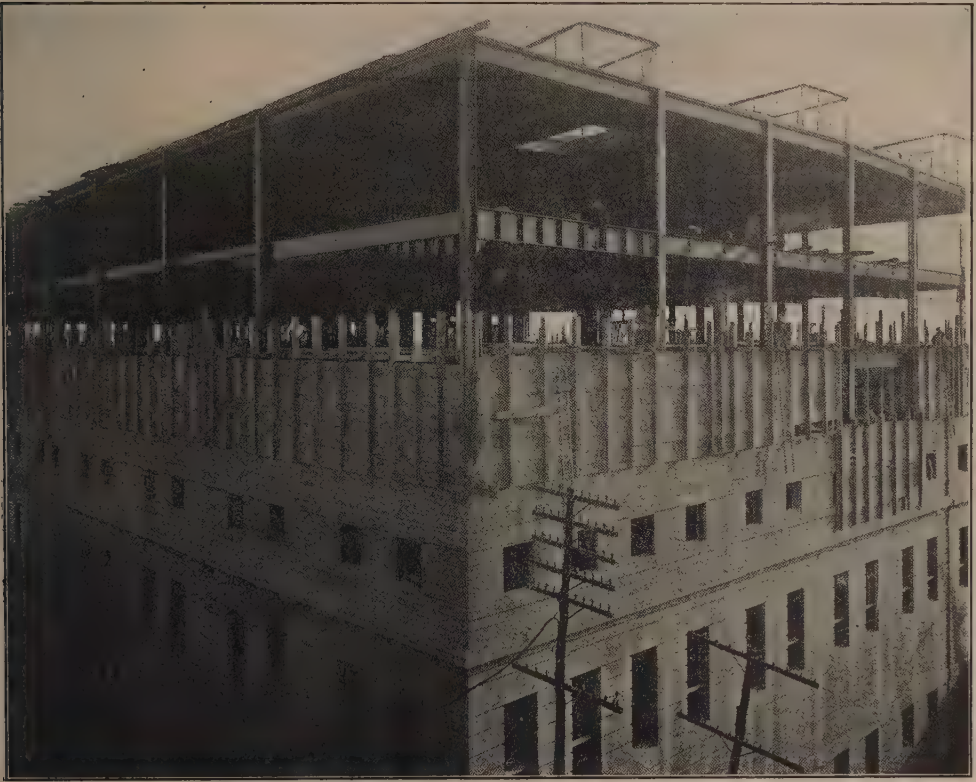
Concrete was raised to the different floors by a contractors' platform elevator driven by a steam hoisting engine. The concrete was discharged by the mixers into specially designed carts having a capacity of 6 cu. ft., consisting of a bucket swung between two high spider wheels. They were easily handled by one man and when raised to the floor on which the concrete was needed were run onto plank runways laid on the steel work and wheeled to the point where the concrete was being placed. The use of these carts required the erection of some extra scaffolding, but that was fully paid for by the increased capacity of the carts over wheelbarrows.

The concrete was put in in sections, generally from the top of the windows to the sill of the windows above, and then the piers between the windows were put up. Where the height was too great for these sections to be put in in one operation, work was stopped and levelled off at the height of one of the V-shaped horizontal joints. In the top surface of each section steel dowels were embedded in the concrete, sticking up about 5 in. with an inverted V projection to prevent any water which might be driven into the horizontal joints, from passing to the inside face of the walls. Vertical expansion joints were provided about once in 50 ft., finished with a V-shaped joint on the outside or concealed in the angles formed by the offsets of the outside walls. The concrete was placed in the forms for the walls by being dumped into a sheet iron hopper, attached to the bottom of which was a telescope canvas chute, the lower part of which was kept just above the concrete already deposited This prevented any splashing as the concrete was placed in the forms and aided materially in getting a good surface. The forms were not coated with any special materials to prevent the concrete from sticking to the boards any more than to keep the wood thoroughly wet before the concrete was put in. The concrete was in a very plastic state and was thoroughly spaded to remove all air bubbles and to push back the stone from the fact of the wall.

The building being of skeleton steel construction, permitted of attaching the forms to the steel frame in such a manner as to absolutely insure stability and accuracy. On each tier of beams outriggers were placed which were securely fastened to the beams by special steel clips which were easily removed. To these outriggers the uprights or studding were bolted and the plank forms were attached to the studding in sections, the outside of the form in many cases being used several times without being taken apart. The inside section, however, had to be practically rebuilt each time the form was raised.

The ⅝-in. bolts which held the forms together were passed through moulded concrete blocks about 4 in. square which had been prepared beforehand and allowed to season. The blocks were of the same length as the thickness of the walls, and the hole being ¾ in. in diameter allowed the bolts to be readily withdrawn when the forms were struck. They were moulded into the walls and when the forms were removed the holes were filled with cement mortar.

The delay in erecting the steel work, due to the strike of the iron workers last year, prevented the enclosing walls being built before the cold weather set in last fall and when the steel work was finally completed the novel experiment was tried of putting on the roof before any of the floors were constructed. After the roof was made watertight the centering which was built for the reinforced concrete of the roof was lowered to the floor below and there formed the centering for the sixth floor. This was repeated from floor to floor and reduced the cost of removing the centering to a minimum. This procedure had the added advantage of preventing the drip from the floors as the concrete was laid from injuring the floors below as would have been the case if they had been laid from the bottom going up. The enclosing walls were carried up and connected with the roof before the severe cold weather of January. The windows were then closed and the work on the floors continued by the use of salamanders throughout the winter, no damage being done by the frost.


Method of Constructing Walls with Shutter Forms.

The building was designed and constructed under the general direction of Mr. Jos. O. Osgood, engineer of the Newark Warehouse Co., by the John W. Ferguson Co., Paterson, N. J., and New York City. Mr. Wm. Verbaarschot was the superintendent for the contractor and Mr. A. W. Smith represented the Newark Warehouse Co.

Heavy Galvanized Sheets are in use on the Northern Pacific Ry. for the decks of wooden bridges to guard against fire, as the burning of timber bridges is mainly due to hot cinders from the ash pans of locomotives. Galvanized sheets are put on in 8-ft. lengths with copper rivets, the rails being laid on top of the sheets and spiked through. Bolts for the bridge timbers are also passed through the sheets and at the ends of the bridge decks the sheets are flashed under the first tie of the road bed on either end and no part of the framework is exposed.

The Massachusetts Position Regarding Pollution of Streams by Mill Wastes.

The brief note in this journal on Aug. 3, concerning the decision of the Massachusetts Supreme Judicial Court in Parker v. American Woolen Co. has interested so many readers that the text of the court's statements regarding stream pollution are reproduced below without change.

It is difficult, if not impossible, to reconcile all the decisions which have been made upon the question of the right of riparian proprietors to use the waters of streams flowing through or along their lands. This is a common right, and each must exercise it with all due regard to the rights of others, and each must submit to that degree of inconvenience and hardship in the exercise of his rights which results from the existence of like rights in others. In such cases, each proprietor is entitled to use the stream in such reasonable manner, according to the usages and wants of the community, as will not be inconsistent with a like use by other proprietors above and below him. Cary v. Daniels, 8 Metc. 466, 41 Am. Dec. 532; Thurber v. Martin, 2 Gray, 394, 61 Am. Dec. 468; Gould v. Boston Duck Co. 13 Gray, 442. Many of the decisions relied upon by the defendant are instances of the application of this rule. Pitts v. Lancaster Mills, 13 Metc. 156; Springfield v. Harris, 4 Allen, 494, 81 Am. Dec. 715; Jones v. Portsmouth Aqueduct, 62 N. H. 488; Snow v. Parsons, 28 Vt. 459, 67 Am. Dec. 723; O'Riley v. McChesney, 49 N. Y. 672.

Cases in which the proprietors of sawmills have been allowed to throw sawdust and similar refuse into the streams frequently for the reason that the mills practically could not be run unless this was allowed to a reasonable extent, generally have been put upon the same ground. Haskins v. Haskins, 9 Gray, 390; Hayes v. Waldron, 44 N. H. 580, 84 Am. Dec. 105; Jacobs v. Allard, 42 Vt. 303, 1 Am. Rep. 331; Canfield v. Andrew, 54 Vt. 1, 41 Am. Rep. 828; Prentice v. Geiger, 74 N. Y. 341. But permission to do this has been refused where it was found to make the water impure and unfit for drinking and domestic purposes. Lewis v. Stein, 16 Ala. 214, 50 Am. Dec. 177. And the tendency of the later decisions is to restrict somewhat the liberality of the original rule. Lockwood Co. v. Lawrence, 77 Me. 297, 52 Am. Rep. 763; Canfield v. Andrew, 54 Vt. 1, 41 Am. Rep. 828; Red River Roller Mills v. Wright, 30 Minn. 249, 15 N. W. 167, 44 Am. Rep. 194. And in Canfield v. Andrew, supra, the court is careful to say in its opinion that no one is allowed to deposit any substance in a running stream that will pollute its waters to the injury of a lower riparian proprietor.

It is of course true that many of the uses which properly may be made of the water of a natural stream by the upper riparian proprietors will be likely to tend somewhat to defile the water. Sprague v. Dorr, 185 Mass. 10, 69 N. E. 344. Its use for watering cattle and for the irrigation of fertilized land, or for bathing or other domestic purposes, will have directly that tendency. Water cannot be made to pass through the propelling machinery of a mill without becoming more or less impure; nor can the water be made available for any manufacturing use without some incidental deterioration of its quality. Surface drainage into the stream will become more and more injuroius to the condition of the water as population along its banks grows denser. No one has the right to complain of injury to the quality of the water coming from any of these causes. Wells, J., in Merrifield v. Worcester, 10 Mass. 216, 219, 14 Am. Rep. 592. The natural flow of surface drainage from occupied land or from streets, though much increased by the adoption of newer systems, so as materially to injure the water of a brook into which it runs, will afford no cause of action to a lower riparian proprietor. Bainard v. Newton, 154 Mass. 255, 27 N. E. 995. Perhaps the decision in Pennsylvania Coal Co. v. Sanderson, 113 Pa. 126, 6 Atl. 453, 57 Am. Rep. 445, can be justified upon the ground that the injury there complained of resulted in reality from the water pumped from the plaintiff's mine having drained over the surface of the ground into the brook; upon which reason indeed it is partly rested in the opinion of the court. See Crossley v. Lightowler, L. R. 2 Ch. 478.

We regard it however as settled that no riparian proprietor has the right to use the waters of a natural stream for such purposes or in such a manner as will materially corrupt it to the substantial injury of a lower proprietor, or to cast or discharge into it noxious and deleterious substances which will tend to defile the water and make it unfit for use. This was the doctrine laid down in Wood v. Ward, 3 Exch. 748. It has been maintained in the English courts. Mason v. Hill, 5 B. & A. 1; Pennington v. Brinsop Hall Coal Co., L. R. 20 Eq. 769, 772. It is affirmed in our own decisions. In Merrifield v. Lombard, 13 Allen, 16, 90 Am. Dec. 172, it appeared that by the mode in which the defendant had conducted his business a large quantity of poisonous and corrosive substances was permitted to run into a stream, which defiled and corrupted the water to such an extent that the machinery in the plaintiff's mill, lower down on the same stream, was corroded and his use of the water for proper purposes was impaired and prevented; and the defendant was enjoined from continuing so to act, and the court said: "We know of no rule or principle of law by which such a mode of appropriation of a running stream, in the absence of any proof of a paramount right or title, can be justified or excused as against a riparian owner of land on the same stream below." In Dwight Printing Co. v. Boston, 122 Mass. 583, it was held that a riparian owner has no right, in the absence of express grant or prescription, to use the waters of a stream for dyeing or printing woolen or cotton cloths in such a way as to pollute the water and render it unfit for drinking purposes.

The same doctrine has been incidentally affirmed in other decisions of this court. Washburn & Moen Manuf. Co. v. Worcester, 153 Mass. 494, 497, 27 N. E. 664; Walker Ice Co. v. American Steel & Wire Co., 185 Mass. 463, 471, 70 N. E. 937; New England Cotton Co. v. Laurel Lake Mills, 190 Mass. 48, 52, 76 N. E. 231. There is nothing inconsistent with it in Harris v. Mackintosh, 133 Mass. 228. It has been repeatedly and strongly declared in other states. "Riparian proprietors, mill owners or others have no right to render the water of a stream unwholesome or offensive." Richmond Manuf. Co. v. Atlantic De Laine Co., 10 R. I. 106, 14 Am. Rep. 658; Silver Spring Bleaching Co. v. Wanskuck Co. 13 R. I. 611 (in which the court said: "The right of every owner of land bordering on a stream to the use of the water is well settled; and the fact that he also owns a mill does not lessen his rights. * * * And he has a right to have the water pass his land in its natural, pure state"); Bradley v. Warner, 21 R. I. 36, 41 Atl. 564; Holsman v. Boiling Spring Bleaching Co. 14 N. J. Eq. 335; Chapman v. Rochester, 110 N. Y. 273, 18 N. E. 88, 1 R. A. 296, 6 Am. St. Rep. 366; Middlestadt v. Waupaca Starch & Potato Co., 93 Wis. 1, 66 N. W. 713. In all these cases, it was held that the right of the lower riparian proprietor to the free use and enjoyment of the water of a natural stream extended as well to its quality as to its quantity. And see the cases cited in Gould on Waters, § 219; Wood on Nuisances, 427 et seq; Angell on Water Courses, § 136 et seq. The right to use the stream to carry away mere waste matter in a reasonable manner and to a reasonable extent is not so to be extended as to include a right to discharge into the stream noxious and deleterious matter to such an extent as sensibly and materially to foul the water and destroy its purity and fitness to be used by others.

It is true of course that there is in any large body of water a purifying principle which will, either by ordinary sedimentary deposit or by chemical change, obviate the evil effects which otherwise would arise from the deposit therein of some limited amount of noxious matter. Accordingly it is not for every small deposit of such matter that the law will give a remedy. This was the case in Brookline v. Mackintosh, 133 Mass. 215. There doubtless must be a material and sensible deterioration of the quality of the water; and this was recognized in the rulings made by the single justice. So in Townsend v. Bell, 167 N. Y. 462, 60 N. E. 757, it was found as a fact that the defendant's use of the stream did not render its waters unfit for manufacturing, mechanical or domestic purposes. Merrifield v. Worcester, 110 Mass. 216, 14 Am. Rep. 592, was decided on the doctrine that a city is not to be held in damages for having adopted an improper sewerage system.

Nor can we doubt that the plaintiff is entitled to an injunction to restrain the defendant from continuing to pollute the stream, in order to prevent it from gaining a prescriptive right, even though such pollution does not interfere with any use of the water which the plaintiff is now making. Crossley v. Lightowler, L. R. 3 Eq. 279; Pennington v. Brinsop Hall Coal Co., L. R. 20 Eq. 769, 772; Brookline v. Mackintosh, 133 Mass. 215, 224. And it follows from what we have already said that the plaintiff is entitled to an injunction which will restrain the defendant from discharging into the stream any noxious or offensive substances to such an amount or in such a quantity as to affect noticeably or appreciably the purity of the water when it reaches the plaintiff's premises so as to render it materially less fit for drinking or for other uses than it was when it entered the defendant's premises. Simpson v. Hoddinott, 1 C. B. (N. S.) 590; Merrifield v. Lombard, 13 Allen, 16, 90 Am. Dec. 172; Richmond Manuf. Co. v. Atlantic De Laine Co., 10 R. I. 106, 14 Am. Rep. 658; Holsman v. Boiling Spring Bleaching Co., 14 N. J. Eq. 335. The court can fix no standard of reasonable use which will be more favorable to the defendant, or restrict any farther the terms of the injunction to be issued. The defendant must at its peril see that it does not overpass this limit.

Nor can an injunction properly be refused on the ground of the magnitude of the defendant's interests and the importance of its business. Some stress was laid upon this consideration in Pennsylvania Coal Co. v. Sanderson, 113 Pa. 126, 6 Atl. 453, 57 Am. Rep. 445; but the case was decided on other grounds. The same argument was urgently pressed to no purpose in the somewhat similar cases of Lockwood Co. v. Lawrence, 77 Me. 297, 52 Am. Rep. 763, Silver Spring Bleaching Co. v. Wanskuck Co., 13 R. I. 611, and Holsman v. Boiling Spring Bleaching Co., 14 N. J. Eq. 335. And here, as in the case last cited, the effect of the injunction will not be to stop the defendant's works or to interfere with its manufacturing industry, but simply to restrain it from discharging offensive matter into the stream and thereby polluting the waters which flow through the plaintiff's land. Here, as in that case, it does not appear that the offensive matter cannot readily and at small expense be otherwise disposed of; if a system of filtration or other purification is necessary, the expense of this should not be thrown upon the plaintiff. Richmond Manuf. Co. v. Atlantic De Laine Co., 10 R. I. 106, 14 Am. Rep. 658. Nor is it material that other causes have contributed to the pollution of the stream. This does not excuse the defendant for its wrongdoing. Crossley v. Lightowler, L. R. 3 Eq. 279. This is the principle of Corey v. Havener, 182 Mass. 250, 65 N. E. 69, and Oulighan v. Butler, 189 Mass. 288, 293, 75 N. E. 726. Nor is this a case in which the defendant is simply discharging noxious matter into an already polluted stream. It is expressly found by the master that the water when it reaches the defendant's premises "is good, clean, clear brook water, fit for any kind of manufacture or for domestic use."

Tracing Cloth makes a good window shade in drafting rooms where the sunlight from an unshaded window is too strong. It is also useful in shading electric lights.

Experiments With a Jewell Filter at the Posen Water Works.

By E. A. Gieseler, C. E.

Posen is a city of about 140,000 inhabitants, and the capital of the German province of the same name. It is an important fortress and for this reason it is imperative that the sources of its water supply should be located within the fortified lines.

The present supply is drawn from wells bored into the top layer of sand down to the underlying clay, which is reached at a depth of from 7 to 15 meters. This water, the so-called "Eichwald" water, is practically sterile, but contains a great deal of iron. It is conducted through a length of about 4,000 meters of 450-mm. syphons to the works in the city. There the water is aerated and filtered through slow sand filters. After having passed through these it is quite clear, and in every way satisfactory for household use.

This present daily supply of about 18,000 cub. met. is not sufficient for the growing needs of the city. Two ways are open to obtain an increase. The first one consists in a more exhaustive utilization of the present sources of supply by boring additional wells and by pumping instead of syphoning. The second way open for an increase of supply consists in the utilization of water which is also found within the fortified lines in abundant quantities at a depth of from 100 to 150 meters over a stratum of brown coal and which rises in the bored wells above the surface of the soil. From its contact with the coal this so-called "Herzog" water is of a deep brown color (about 1,000 degrees, according to the platinum-cobalt standard), but it is practially sterile, clear, without odor and taste and does not contain any objectionable substances. If it were not for its deep brown color, it would probably be fit for household use in its natural state.

Table 1.—Analyses of Eichwald and Herzog Waters and a Mixture of Equal Parts of Each.

	Eichwald.	Herzog.	Mixture.
Clearness	Clear	Clear	Turbid, but clear when filtered
Color (Plat. Cob. standard)	30° to 40°	1000°	600°
Smell	Slightly H_2S	Slightly peaty	Slightly peaty
Taste	Strong iron	None	None when filtered
Reaction	Weak alkaline	Alkaline	Weak alkaline
Suspended matter—			
Total	0	0	80 unfiltered
Loss on ignition	....	0	56 “
Residue on ignition	....	0	24 “
Residue on evaporation—			
Total	464	645	462 filtered
Loss on ignition	68	164	64 “
Residue on ignition	396	481	398 “
Chlorine	18	178	98 “
Ammonia	0.7	2.6	Trace “
Nitrates	0	0	0 “
Nitrites	0	0	0 “
Iron, Fe_2O_3	18	0.9	Trace “
Manganese, Mn_2O_3	1.7	0	0 “
Lime, CaO	123	61	70 “
Magnesia, MgO	21	20	16 “
Silicic acid, SiO_2	28	6	12 “
Sulphuric acid, SO_3	39	31	33 “
Phosphoric acid, P_2O_5	Trace	Trace	0 “
Oxygen, O	0	0	0 “
Carbonic acid—			
Free	16		.... “
Half free	94	46	.... “
Combined	94		.... “
Temporary hardness	12.3	6.6	6.2 “
Permanent hardness	2.9	2.4	2.5 “
Organic carbon	....	29	.... “
Permanganate of potassium consumed	24	246	12 “
Bacteria per c.cm	20 to 70	1 to 4	.... “

Laboratory experiments have shown that when a mixture is made of Herzog and Eichwald water in certain proportions, then the color of the former and the iron of the latter are precipitated without any previous aeration being required. After removing the flocculent precipitate of this mixed water by filtration, a perfectly clear and sterile potable water is obtained. The coagulating action of the two waters on each other takes place very rapidly when both are fresh from the soil, while when they are not fresh from the soil a certain period of subsidence is required, the length of which seems in a measure to depend on the time elapsed between pumping and mixing the two waters. A paper has been published on the subject by Prof. Dr. Wernicke and Dr. Weldert in "Mitteilungen aus der Koeniglichen Pruefungsanstalt fuer Wasserversorgung und Abwaesserbeseitigung, Heft 8, 1907." From this paper the analysis of the two waters given in Table 1 has been taken.

The remarkable result obtained by mixing the two waters is ascribed by Professor Wernicke and Dr. Weldert to the action of the iron in the Eichwald water on the humic substances contained in a very finely divided state in the Herzog water. I quote again from the above mentioned paper as follows:

"Tests made for the purpose of determining the nature of the substance causing the brown color of the Herzog water have shown that this substance is not held in solution, but in colloidal solution, because in the first place the colloid becomes pectenised when heated to the boiing point, and, secondly, because, as is apparent from the following table, it does not diffuse through parchment:

Duration in Hours of Dialysis Test.	Chlorine mg. per Liter.	Permanganate of Potassium Consumed.
0	174	228
48	119	226
120	64	222

"Further tests have shown that the amount of colloid is about 60 mg. per liter when dried at a temperature of 110° C. The analysis of this residue has rendered the following result: Organic carbon, 7 per cent.; nitrogen, 3 per cent.; residue on ignition, 22; loss on ignition, 78 per cent.

"The residue on ignition, besides a small quantity of iron, consists principally of lime respectively magnesia and silicic acid . . . . . . The mixture of one part Herzog and one part Eichwald water, when filtered immediately after mixing, renders a clear effluent of a slightly yellowish color (7 to 12 degrees) and free of iron . . . . . . The mixing of the two waters was tested in various proportions and it was found that the best proportion was between the limits of three parts Eichwald water to from two to seven parts Herzog water, in other words that 1 liter of the Eichwald subsoil water containing iron would remove the color of from 0.6 to 2.1 liters of the brown Herzog subsoil water and at the same time be freed of the iron contained in it. On the basis of these figures we can compute that 1 mgr. of iron precipitates from 2.2 mgr. to 7.0 mgr. of the brown coloring substance.

"Professor Wernicke's tests had shown that besides the proportion in which the two waters are mixed, the age of the water containing iron (the Eichwald water) was likewise of importance, in other words that the time elapsing between the taking of the Eichwald water from the well and the mixing of the two waters exerted an influence on the reaction. The brown deep subsoil water was indifferent in this respect. It found that the longer the Eichwald water was kept without special care being exercised, the slower the reaction would be. After all iron of the Eichwald water had been precipitated as hydroxide no reaction at all would occur.

"This is of importance as regards the theoretical explanation of the reaction. It corroborates Professor Wernicke's opinion that the precipitation of the brown color is caused by the iron contained in the Eichwald water, but only by such iron which is held in solution."

In view of these remarkable laboratory results it was decided to conduct experiments with a filter furnished by the Jewell Export Filter Co. with a view to demonstrating whether and under what conditions of subsidence and coagulation the Herzog water alone or a mixture of it and the Eichwald water could be made potable on a large scale, or, failing that, whether rapid filtration would deal as successfully with the aerated Eichwald water as the present slow sand filter does.

The experiments were made with a plant consisting of a 4-ft. Jewell filter, two subsidence tanks and a chemical apparatus, all of which were arranged in the usual way. The two subsidence tanks had an aggregate capacity of 18 cu. m., but this capacity was later on increased by the addition of further tanks.

TABLE 2.—EXPERIMENTS WITH JEWELL FILTER AT POSEN.

No. of Test.	Rate of Filtration in 24 Hrs., Meters.	Duration of Subsidence.	$Al_2(SO_4)_3$ gr. per cbm.	Satisfactory Effluent per m² Filter Area During 1 Run.
Mixed water with sulphate of alumina.				
1	120	2 hrs. 50 m.	55	38 cub. met.
6	120	4 hrs. 26 m.	30	25 " "
7	120	4 hrs. 26 m.	31	18 " "
8	120	4 hrs. 26 m.	31	18 " "
9	120	4 hrs. 26 m.	31	20 " "
10	120	4 hrs. 26 m.	52	27½ " "
2	93	4 hrs. 00 m.	107	*a*47 " "
3	93	4 hrs. 00 m.	88	53 " "
4	93	4 hrs. 00 m.	50	*a*23 " "
12	93	5 hrs. 40 m.	60	56½ " "
13	93	5 hrs. 40 m.	30	46½ " "
5	60	5 hrs. 40 m.	50	81 " "
Herzog water with sulphate of alumina.				
14	120	2 hrs. 50 m.	52	33 cub. met.
15	120	2 hrs. 50 m.	68	48 " "
Mixed water without sulphate.				
16	120	4 hrs. 26 m.	0	12½ cub. met.
17	120	4 hrs. 26 m.	0	12½ " "
18	93	20 hrs. 00 m.	0	*b*43 " "
19	93	20 hrs. 00 m.	0	15½ " "
20	62	8 hrs. 36 m.	0	46 " "
21	62	8 hrs. 36 m.	0	*c*49 " "
22	62	19 hrs. 00 m.	0	44 " "
23	45½	13 hrs. 00 m.	0	68½ " "
24	32½	12 hrs. 15 m.	0	*b*80 " "
25	32½	12 hrs. 15 m.	0	60 " "
26	32½	12 hrs. 15 m.	0	65 " "
27	32½	17 hrs. 00 m.	0	*b*150 " "
28	32½	17 hrs. 00 m.	0	100 " "
29	32½	37 hrs. 00 m.	0	*b*130 " "
30	32½	56 hrs. 30 m.	0	*d*194 " "
31	32½	56 hrs. 30 m.	0	*d*114 " "
32	16¾	24 hrs. 00 m.	0	94 " "
33	11.8	34 hrs. 00 m.	0	126 " "
Eichwald water without sulphate.				
34	93.4	3 hrs. 45 m.	0	*e*643 cub. met.
35	120	1 hr. 30 m.	0	*f*379 " "
36	120	1 hr. 30 m.	0	548 " "
37	120	1 hr. 30 m.	0	461 " "

a, Test not concluded.
b, With preliminary filter.
c, Milk of lime was poured on filter.
d, With preliminary filter; effluent good until end.
e, Effluent contained 0.1 mg. of iron; color of effluent, 7 to 12.
f, Effluent free from iron.

Experiments were commenced on Aug. 1, 1906, and were concluded on March 31, 1907. They included the treatment of mixed Herzog and Eichwald water alone without the use of sulphate of alumina and the treatment of Eichwald water alone without the use of sulphate of alumina.

It may be stated generally that the results obtained with the water containing iron were entirely satisfactory in regard to the quality of the effluent as well as in regard to the length of runs and the percentage of wash water required. The experiments with Herzog water were likewise successful so far as the removal of color was concerned, but they were not as sucessful as the one previously mentioned, either in regard to length of run and quantity of effluent furnished during one run, nor in regard to the percentage of wash water required. It was found, especially when using high rates of filtration, that the color would penetrate the filter bed after a comparatively short time. The results obtained are given in the appended tables, from which the conditions may be seen under which each individual test was made and how much water was satisfactorily clarified per square meter of filter bed during one run under such conditions. The limit of satisfactory clarification (removal of color) has been assumed at 15 degrees of the platinum-cobalt standard.

We will first consider the tests during which sulphate of alumina was applied, a summary of which is given in Table 2. No great difference was apparent in the action of sulphate of alumina on the pure Herzog water and on the mixed water. From a consideration of the figures of both tables we arrive by means of interpolation at the results given in Table 3, regarding the amount of water that can be satisfactorily clarified during one filter run:

TABLE 3.—AMOUNT OF SATISFACTORY EFFLUENT OBTAINED PER SQUARE METER OF FILTER AREA DURING ONE RUN. MIXED WATER WITH APPLICATION OF $Al_2(SO_4)_3$.

Rate of Filtration, Meters in 24 Hours.	When Applying per Cubic Meter 30 gr. $Al_2(SO_4)_3$.	50 gr. $Al_2(SO_4)_3$.
120	20 cub. met.	30 cub. met.
110	28 " "	38 " "
100	36 " "	47 " "
90	45 " "	55 " "
80	53 " "	63 " "
70	61 " "	72 " "
60	70 " "	80 " "

It is clear at once from Table 3 that the high rates of filtration as well as the very low ones are practically out of question, because in the former case the filter runs are too short and in the latter case the required area of filter beds is too great. A rate of filtration of 80 meters when 30 grammes of sulphate of alumina are applied and a rate of filtration of 90 meters when 50 grammes of sulphate of alumina are applied, seem, however, to meet the practical requirements. In view of the considerable hardness of the raw water, there is not the slightest objection against the application of such quantities of sulphate of alumina.

When a rate of filtration of 80 meters is assumed with 30 grammes of sulphate of alumina being applied and a duration of subsidence of about 4 hours, then two daily washings would be sufficient and the amount of wash water used would not exceed 5 per cent. of the effluent. The existing slow sand filter bed in which the proposed rapid filter plant is to be accommodated affords space for fourteen 21-ft. Jewell filters, which with the rate mentioned above would furnish 36,000 cub. met.

During all these tests, the end of the run was brought about by the penetrating through the filter bed of the color, long before the loss of head had reached its highest limit. There is, therefore, no doubt that, if finer sand was to be used than that employed during the experiments, it would be possible to increase the velocity of filtration without at the same time increasing the dose of sulphate of alumina and the number of washings required.

We now have to consider the clarifying of the mixed water without the application of sulphate of alumina. A summary of the results obtained is given in Table 2. Six of these tests have been made with the aid of a preliminary filter and have yielded good results. For instance, with a rate of filtration of 93 meters, a sedimentation of 20 hours and the use of a preliminary filter, 43 cu. met. were obtained per square meter of filtering area in one filter run. A rate of filtration of 80 meters would therefore appear to be practicable and only require two washings in 24 hours. But the quantity of the wash water would certainly be great, as not only the filter proper but also the preliminary filter would have to be washed. Again, the space required for the entire plant would be very large. The tests made without the use of a preliminary filter are numbered 16, 17 19, 20, 22, 23, 25, 26, 28, 32 and 33. Their results have been produced graphically by laying off on the axis of abscissae the rates of filtration and on the ordinates the quantities of clarified water obtained per square meter during one filter run. The points thus obtained could be joined without any considerable deviation by a continuous curve and from this curve the figures of Table 4 have been obtained. This table contains a source of errors, inasmuch as the duration of sedimentation has not been considered.

It varied between 4½ and 34 hours, but for the rates which practically come into question, namely those of about 60 meters, the average duration of sedimentation has been about 14 hours (tests Nos. 20 and 22).

Table 4.—Amount of Satisfactory Effluent Obtained per Square Meter of Filter Area During One Run. Mixed Water Without Application of $Al_2(SO_4)_3$.

With a filtration-rate of 100 met	17 cub. met.
With a filtration-rate of 90 met	22 " "
With a filtration-rate of 80 met	28 " "
With a filtration-rate of 70 met	35 " "
With a filtration-rate of 60 met	43 " "
With a filtration-rate of 50 met	53 " "
With a filtration-rate of 40 met	65 " "
With a filtration-rate of 30 met	79 " "

It is seen that when a rate of filtration of 60 meters and a sedimentation of 14 hours are employed the mixed water can be clarified under conditions that are admissible in practice. Two washings in 24 hours would be sufficient and the above mentioned plant of fourteen 21-ft. filters would supply a daily quantity of 27,000 cub. met. But it would be necessary to construct subsidence basins of very considerable size, and it should also be mentioned that the removal of color in none of these tests was as satisfactory as when sulphate of alumina was applied.

We now have to consider the tests which were made with the Eichwald water alone, without the use of sulphate of alumina. These tests were made with a rate of filtration of 93.4 meter and a subsidence of 3 hours 45 minutes, and again with a rate of filtration of 120 meter and a subsidence of 1½ hour, the raw water being aerated before filtration. In both cases the result was excellent. According to the Royal Hygienic Institute at Posen the effluent was free from iron. At the same time the color was removed almost totally and even towards the close of each run it amount to only 12 degrees. In all cases the filter could be operated until the loss of head had arrived at its highest limit. With the rate of 93.4 meter a quantity of 643 cub. met. were filtered in one run and with the rate of 120 meters an average quantity of 461 cub met. was filtered in one run, as shown in Table 2. The amount of wash water used was considerably less than 2 per cent. of the effluent in both cases.

We may deduce from these results that the rate of filtration for this water may be considerably still more, when coarser sand is used in the filter bed. It is certain that a rate of 140 meters in 24 hours, with two hours of sedimentation, can be successfully employed and that then one daily washing will be perfectly sufficient, the amount of wash water used remaining below 3 per cent. With this rate of filtration the above mentioned plant of fourteen 21-ft. filters would have a daily capacity of 63,000 cub. met.

Table 5.—Sizes of Filter Plants Required at Posen for Different Methods of Supply and a Daily Capacity of 45,000 Cub. Meter.

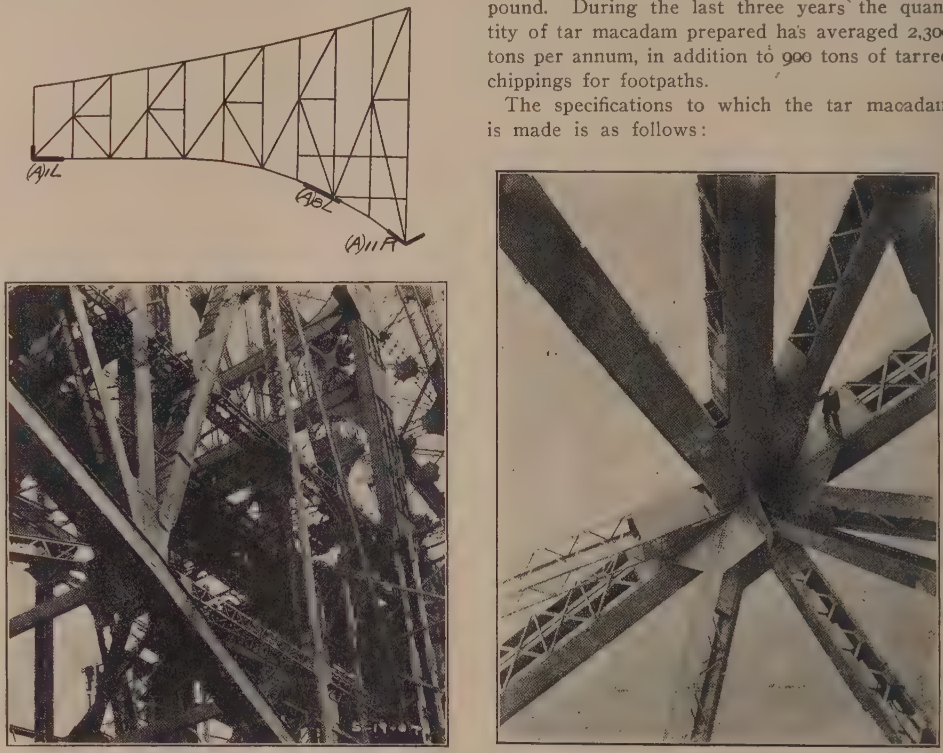
	Rate of Filtration in 24 Hrs.	No. of 21' Filters.	Capacity of Subsidence Required.	Dimensions of Filter House.	Total Area, Including Subsidence.
A	60 m.	24	26,300 cu. m.	93x19 m.	10,500 sq. m.
B	80	18	7,500	77x19	4,000
C	140	10	3,750	38x19	2,000

As stated in the above, the following three methods have been tested to obtain the necessary increase of potable water for Posen: (A), the clarifying of mixed water with application of sulphate of alumina; (B), the clarifying of mixed water without application of sulphate of alumina; (C), the clarifying of the water containing iron without the application of sulphate of alumina. The tests have shown that under certain conditions of subsidence and of rate of filtration all these three methods can be employed in practice, and we find that for a daily capacity of 45,000 cub. met. the size of plant required in each of the three cases is that given in Table 5.

Notes on Tar Macadam.

A paper read at the annual meeting of the Association of Municipal and County Engineers by C. F. Wike, City Surveyor, Sheffield.

These notes are not intended as an argument in favor of better roads. Discussion of road-making problems has recently been so thorough, and the demand for an improvement is so general, that road engineers need now only consider how the desired improvement is to be effected, and how paid for. The necessity has chiefly come about through the rapid development of motor traffic. Those interested in motors disclaim responsibility for the present dust nuisance and blame the roads, upon which, they say, motor vehicles have no more destructive effect than horse traffic. This, however, will scarcely be admitted by those engineers who have charge of the roads. In the opinion of the writer, the additional wear caused by self-propelled vehicles, and particularly by those fitted with non-slip devices, is considerable. Whether such vehicles ought to pay a larger contribution towards the upkeep of the highways is a question which undoubtedly will have to be fought out and settled.



Second Bottom Chord Panel Point from Main Pier, Quebec Bridge.

One effect of the new traffic will be an extension of the paved roads leading out of the towns, and possibly a development in the direction of cheap paving. Another result will be that, where the amount of traffic and rateable value does not warrant the expense of paving, some other construction of road involving the least amount of dust will have to be adopted.

Where paving is too expensive, perhaps the best material for minimizing dust is tar macadam, which is by no means a recent introduction, it having been adopted in some of the Northern and Midland towns for at least thirty or forty years. In Sheffield it has certainly been laid nearly forty years, and it is with regard to what has been done in this direction that the following detailed observations are offered.

At present there are 392 miles of roads, of which 241 miles are macadam roads; about 151 miles of the latter are repairable by the Highway Authorities, and of these, nearly 10 per cent. are laid with tar macadam. The proportion may seem small, but the reason for this at once brings us face to face with one of the difficulties in the general adoption of tar macadam roads.

Many of the roads in the writer's charge have steep gradients, and no one who has had experience of tar macadam will suggest that it is a desirable material for hills. Up to the present a gradient of 1 in 20 has been considered sufficiently steep, and perhaps other engineers will be good enough to give their experience as to laying tar macadam on steeper gradients.

At one time most of this work was let by contract, and this is still the case to a liimted extent but about five years ago a plant was constructed by the corporation at an approximate cost of £1,000, consisting of sheds, iron-plated floors, with flues beneath for drying the broken stone, and heating apparatus for the tar compound. During the last three years the quantity of tar macadam prepared has averaged 2,300 tons per annum, in addition to 900 tons of tarred chippings for footpaths.

The specifications to which the tar macadam is made is as follows:

First Coat.—About 2 in. in thickness of limestone "dark" in color, and of approved quality, sound, hard and free from spar, and equal to sample. The stone to be broken uniformly to a 2¼-in. gauge.

Second Coat.—About 1¼ in. in thickness, of best slag, of sound, uniform material, free from honeycomb and dirt, from approved works, all equal to sample. The slag to be broken uniformly to a 1¾-in. gauge.

Third Coat.—About ¾ in. in thickness of slag shingle to a ¾ in. and ½ in. gauge in equal proportions, free of dust, of the quality specified for the second coat, and eqaul to sample. The total thickness of the tarred material, after being rolled with the steam roller, to be 4 in., and the top of its surface to be ¾ in. above the level of the channels.

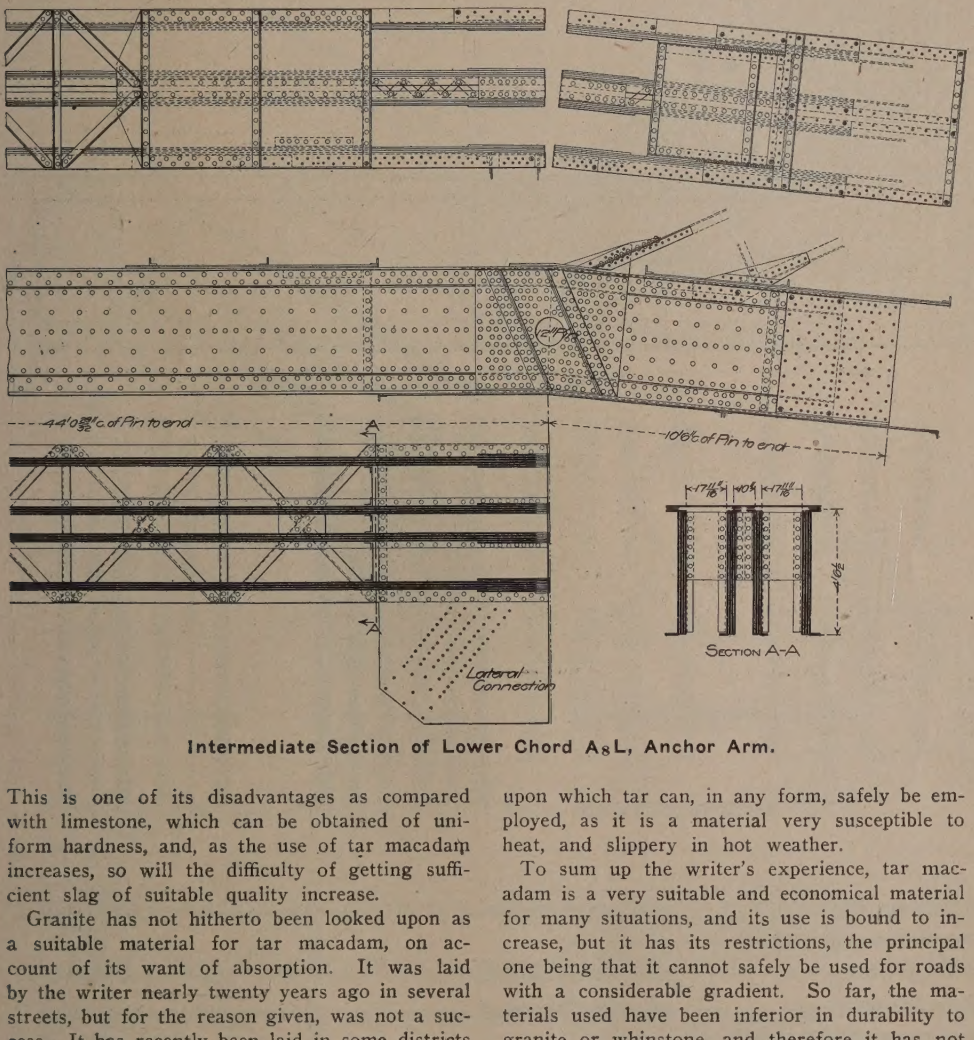
After rolling the roadway is to be covered with a dressing coat of granite chips (½ in. dust out) of approved quality and thickness, as may be ordered, and again rolled.

The whole of the limestone and slag must be thoroughly well dried on hot plates; a mixture of pitch and tar must then be boiled in the following proportion: For the first and second coats 90 imp. gal. tar and 125 lb. of pitch; and after boiling for two hours, 17 imp. gal. of the mixture must be mixed with 30 cwt. of the broken limestone and 1¾ in. slag.

For the third coat 14 imp. gal. of the above mixture, after boiling, to be added to each cubic yard of shingle.

The limestone and slag to be perfectly dry and warm at the time of mixing, and the whole thoroughly turned over, so that every part of the surface of the stones will receive a coating of the mixture. The above-mentioned proportions may vary according to the quality of the pitch and the strength of the tar. The prepared limestone and slag is then to be put in separate heaps, and left a sufficient time to toughen before being laid. After it has been properly toughened and freshened with a further quantity of pitch and tar (if considered requisite), it is then to be spread on the foundation in layers as specified.

The cost of slag and limestone tar macadam is about the same. If of the best quality, probably slag is the better material, and in certain instances, it has been used for all three coats. The difficulty, however, is to get it sufficiently uniform and free from lime and other constituents which render it liable to early disintegration. This is one of its disadvantages as compared with limestone, which can be obtained of uniform hardness, and, as the use of tar macadam increases, so will the difficulty of getting sufficient slag of suitable quality increase.



Intermediate Section of Lower Chord A_8L, Anchor Arm.

Granite has not hitherto been looked upon as a suitable material for tar macadam, on account of its want of absorption. It was laid by the writer nearly twenty years ago in several streets, but for the reason given, was not a success. It has recently been laid in some districts with tarred chips for binding, and similar work is in preparation in Sheffield. If the necessary adherence could be obtained, granite would, on account of its better wearing qualities, be more economical than either limestone or slag, and perhaps, with modern methods of retarring roads at frequent intervals, the old difficulty may be got over.

With regard to the cost of tar macadam roads compared with dry granite macadam, the initial cost is about the same, about *2s. 3d. to 2s. 6d.* per super. yard, exclusive of foundation, the extra expense of tarring being balanced by the fact that a cheaper material is used than the granite macadam usually employed for important main roads, when these are not paved. Statistics have been prepared with regard to a typical suburban road, taking a considerable amount of traffic, and the annual charge (including initial cost) for a period of fourteen years has averaged about *4d.* per square yard; this is for a fairly flat road. In another case—a road with light traffic—the average has been a little less than *2½d.* per square yard.

If the best results are to be obtained, it is very advisable that, after the first laying, tar macadam should be kept in thorough repair, and for many years it has been the practice to tar paint the surface at intervals of three or four years, or as soon as roughness begins to show. This has been done not so much with the idea of laying the dust as to prolong the life of the tar macadam.

At present a considerable mileage of dry macadam road is being tar sprayed, and, so far as can be seen at present, it will be practicable to apply this system to gradients steeper than those upon which tar macadam has been laid. Nevertheless, there must be a limit to the gradients upon which tar can, in any form, safely be employed, as it is a material very susceptible to heat, and slippery in hot weather.

To sum up the writer's experience, tar macadam is a very suitable and economical material for many situations, and its use is bound to increase, but it has its restrictions, the principal one being that it cannot safely be used for roads with a considerable gradient. So far, the materials used have been inferior in durability to granite or whinstone, and therefore it has not been suitable for macadam roads with the heaviest traffic. The great advantages are the comparative absence of dust, and the quietness. Tar macadam roads are also economical in the matter of cleansing. The introduction of tar-spraying apparatus has materially helped to minimize the dust nuisance, and it is through the application of tar, in one form or another, that the nearest approach to a dustless road must be looked for, where paving (which, after all, creates the least dust) cannot be used.

THE TREES ALONG STREETS in East Orange, N. J., are under a Shade Tree Commission, of which Mr. Alfred P. Boller is president. It plants and prunes trees, carries out measures to destroy insect pests, and repairs injured trees.

The Quebec Bridge Superstructure Details.—Part VII.

Anchor Arm Bottom Chords.—The bottom chords of the anchor arm trusses form chords of parabolic curves with 500-ft. span and 112 ft. rise, divided into ten panels of a uniform horizontal projection of 50 ft., which, at the river end where the inclination is nearly 45 deg., gives a maximum length of about 68 ft. on centers. All vertical and sub-vertical posts are connected to the lower chords with 12-in. pins and the connections of the diagonal members of the trusses are made through the lower ends of the vertical posts so that they are not directly attached to the chord members.

The bottom chords have a uniform rectangular cross section 4 ft. 6 in. deep and 5 ft. 7½ in. wide, made with four built channels with the thicknesses of their webs and the sizes of their flange angles varied to correspond with the total cross-sectional areas of 301 to 776 sq. in. The top flange angles on the two inner channels are turned inward. All other flange angles are turned outward. The flanges are connected by ½-in. batten plates at the splices and between them are divided into panels about 5 ft. long by transverse 3x3-in. angles. Each panel is X-braced with 3x3-in. lattice bar angles having two rivets in each end. On the top flange both of these angles are continuous, one of them having its vertical flange cut to clear the other. They are riveted together at the intersection and have one rivet in each flange of the chord channels. Batten plates are riveted across the lower flanges of the inner channels of the chords where the lattice angles intersect them and serve as splices for one of the latter, which is cut to clear the other, running continuously across it and secured with four rivets. At panel points the lower bottom plates project beyond the inner face of the chord to form, with parallel plates field riveted through the upper flanges opposite them, jaw plates for the field riveted connection of the lateral struts and diagonals.

As the chords change direction at panel points they are cut through there, and have at these places radial butt-joints spliced with shop-riveted web cover plates one on each side of the outside webs and one on the outside only of each of the inside webs. In order to facilitate erection the field riveted splices between the bottom chord sections are made at points 10½ ft. beyond the panel points on the river side. This arrangement enables all members to be connected at any given panel point without assembling the lower chord section for the next panel.

The eighth panel from the anchorage of the bottom chord is typical of the intermediate panels in the anchor arm truss, is 54½ ft. long over all and weighs 164,000 lbs. It has a maximum stress of 15,079,000 lb., and a gross cross sectional area of 767 sq. in. Each channel is made with three 54x13-16-in. and one 37¾x13-16-in. web plates riveted together with five lines of rivets exclusive of two lines in the vertical flange of each of the two 8x6x15-16-in. flange angles. The ends of the chords are stiffened in the field splices by vertical diaphragms and the field splices are made with 1-in. rivets through the webs of the outer channels and 1-in. turned-bolts through the webs of the inner channels which are inaccessible for field riveting. The open holes enclosed by hexagons, in the drawings, indicate shipping bolts.

The bottom chord in the river end panels of the anchor arm truss is 39 ft., 2⅞-in. long over all and weighs 120,000 lbs. It has a maximum stress of 16,129,000 lb. and a cross sectional area of 842 sq. in. The outer ribs are each made with two 54x15/16 in. web plates, two 46x15/16-in. side plates and two 8x3½x15/16-in. flange angles. The inner ribs are each made with three 54x15/16-in.

web plates, one 37¾x15/16-in. side plates, and two 8x6x15/16-in. flange angles. This section of the chord is special in that it has no pin connection, the connection to the main vertical post over the center pier being made with a riveted splice to the short section engaging the pedestal at this point.

The bottom chord section in the shore end panel of the anchor arm truss is special on account of the connections for the inclined end bars and the vertical portal post and the provisions made for the group of vertical anchorage bars connecting it to the reaction platform in the bottom of the pier. This section is 43 ft., 1⅜-in. long over all and weighs 119,000 lb. Its maximum stress of 4,950,000 lb. is less than that of any other section of the bottom chord and is provided for by a cross sectional area of 301 sq. in. The ribs are each made with a single 54x15/16-in. web plate and two 8x6x15/16-in. angles and are divided into 4½-ft. panels by inside vertical 3x3-in. stiffener angles. The river end of this cross ection is like those of the other pieces except that the splice is made on the shore side of the pin. At the shore end the flange angles terminate about 2 ft. from the panel point and the webs project 2 ft. beyond it and are bored for a 10½-in. pin engaging the vertical anchorage eyebars. A slot 1 in. wide and 4½ ft. long is cut through all of the webs on the center line about 6 ft. clear of the panel point to receive a 53x¾-in. horizontal diaphragm plate about 5 ft., 2 in. long, which is connected by a pair of horizontal angles to each of the webs and affords connection for two intermediate vertical webs. The main webs are spliced about 10½ ft. from the end of the chord to short end sections 120 in. wide and 15 in. thick, which, with the two intermediate diaphragms of similar shape, provide 6 wings or jaws, engaging the foot of the inclined end bars with the 12-in. pin on heavily reinforced bearings. The plates extend beyond the pin hole to the end of the chord and above it are connected and stiffned by two sets of transverse diaphragm plates, thus making a massive rectangular pillar field riveted to the double end floor beam and receiving from it the heavy lateral stresses which are transmitted to the masonry pier.

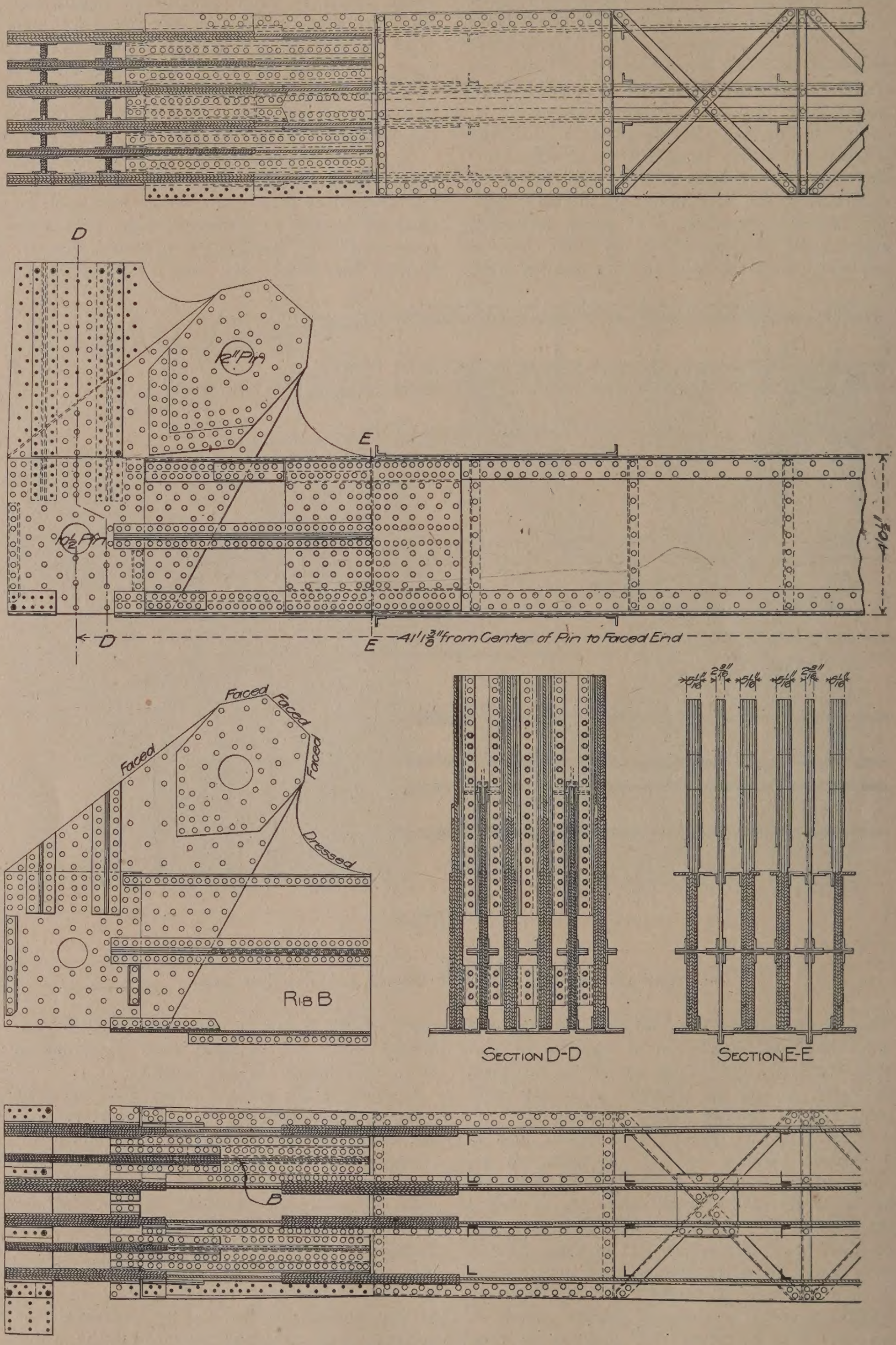
The bottom chords in the anchor and cantilever arm are connected together over the river pier by a special V-shaped section about 23 ft. long and 9 ft. high over all exclusive of end splice plates, which weighs about 40 tons and was riveted up complete in the shop and shipped as a single piece. It has 4 massive webs corresponding with those of the chord sections and is bored at the intersection of the center lines of the two wings, to engage the 24-in. pin through the foot of the main post. The webs interlock with those of the shoe and pedestal and provide full hole bearings of an aggregate length of 15 in. The ribs are made in halves with vertical butt joints on the center lines, each half rib has 4 full-length 15/16-in. web plates and two 6x8x15/16-in. flange angles. The halves of each web are spliced together by two cover plates on each side which are continuous across the center line and are bored with full pin holes.

The webs are connected on each side of the pin by three sets of oblique solid plate diaphragm, one of them parallel and one perpendicular to the axis of the chord and the third one making an angle of about 30 deg. with it. Except near the vertex, the flanges are connected by top and bottom cover plates with open holes to match those in the inclined plates shop riveted to the shoe and pedestal with which they are field riveted or bolted. Four lateral connection plates with maximum dimensions of 117¾x½x120 in. are shipped loose and are field riveted to the top and bottom flanges as indicated in the general plan and elevation to receive the main bottom lateral members. The outer edges of these wide plates are stiffened by single 6x4-in. angles.

(To be Continued.)

Open Tank Timber Treatment.

The open tank treatment of timber is rapidly gaining favor, according to the Forest Service of the Department of Agriculture. The reason for this is that the appliances necessary for the treatment can be readily transported from place to place and are comparatively inexpensive, whereas the retorts and other apparatus required into the heart of the forest if necessary. An advantage claimed for the process is that it can be applied effectively to parts of timbers which are particularly subject to rapid decay, such as butts of fence posts and telephone poles, without wasting preservatives on other parts. It is also applicable to the treatment of mine props, cross-ties, piles, shingles, and small timbers of loblolly pine, black and tupelo gum. Western yellow pine, lodge-

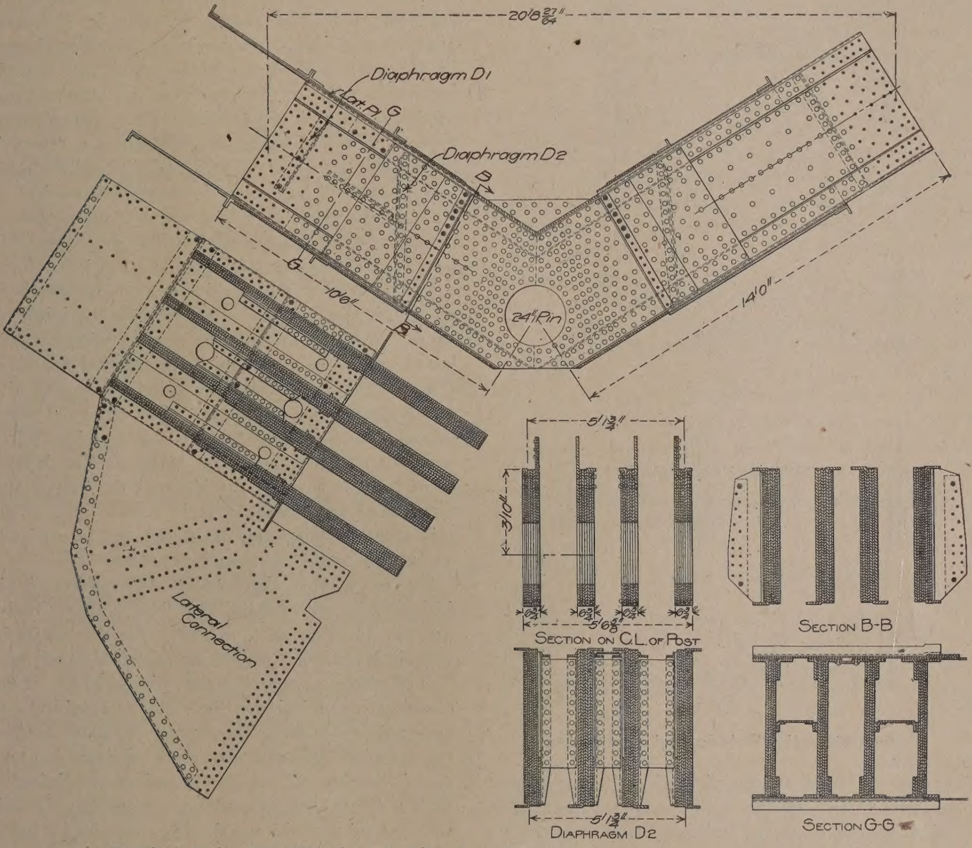


Lower Chord A₁ L at Shore End, Anchor Span, Quebec Bridge.

for the treatment of timber by the older methods are expensive and permanent. Hence, preserving plants have been located at lumber centers as a rule, where a large business might be expected, and the transportation charges to and from the treating plant have been quite heavy. The equipment for open-tank treatment, consisting of an open tank warmed either by steam coils or by a fire below, is so simple and low in cost that it is within reach of small companies and contractors. Moreover, it is so portable that it can be taken pole pine and similar kinds of wood. According to the Forest Service, fairly good results have also been obtained in treating arborvitae, chestnut and red oak, but the experiments thus far made do not warrant the application of the method to the treatment of piles and ties of such woods. While the open-tank treatment does not ordinarily secure so deep a penetration of the chemicals as is secured by the pressure retort method, it is considered sufficient to protect timber for many purposes.

The Concrete Pier at Newlyn Harbor, England

The Newlyn south pier or breakwater, 25 ft. wide on top and 707 ft. long, is built of concrete on solid rock in water of a maximum depth of 14 ft. The concrete was cast in 15-ft. sections in molds made of shutters, placed by divers, on vertical transverse falsework bents. Each bent had a center vertical post and two side posts battered respectively 1:8 and 1:12 to correspond with the inclined faces of the pier. The posts were single 10x10-in. timbers about 40 ft. long, with their lower ends seated in shallow pits excavated in the surface of the bed rock and loaded with sufficient kentledge to overcome their buoyancy. In each transverse bent the posts were connected by horizontal struts bolted across them at just about low water level and at the top. The two upper panels thus formed were X-braced with single 6x6-in. angles and the entire bent considered as a single panel was X-braced with chains reaching from top to bottom of the posts and adjusted by turnbuckles. Similar adjustable transverse guys in the planes of the bents were attached to the tops of the outside posts and were anchored by a weight on the bottom of the bay. The bents were anchored by a weight on the bottom of the bay. The bents were X-braced longitudinally by adjustable chains.



Section of Lower Chord over Pier A_{11} R Connecting Arms, Quebec Bridge.

Before each batter post was sunk one end of a long longitudinal angle was bolted to it, and after it was in position the other end was bolted to the adjacent bent by a bolt with an eye head, which was easily turned by a diver inserting a cross-bar into its eye. Greased eye-bolts also projected through the inclined posts into the interior of the mold, and were easily removed by divers after the concrete was in positon. The shutters or sides of the molds were made in sectional panels, the lower ones having cast-iron cutting edges which not only served to sink them but penetrated into the shallow layer of sand overlying the surface of the rock. These panels were provided with outside vertical cleats projecting above the upper edge and serving as guides to receive the lower edges of the successive upper panels, which were sunk to position by saddle castings afterwards hoisted to the surface by means of lines. The shutter panels were placed and the surface of the rock cleaned by divers, who also leveled off the concrete deposited under water. Up to low-water level the concrete was made 1:8 with large granite stones embedded in it, but was faced with 3 ft. of 1:4 concrete. The upper part of the pier was made with 1:10 concrete with a facing 12 in. thick. The work was executed with hand derricks and cost about $150 per lineal foot.

Subsequently another pier 40 ft. wide and 1,025 ft. long was built with two parallel concrete face walls chained together at distances of 100 ft., and filled between with rubble. As this pier was nearly all built above low-water level, ordinary molds were used for the concrete and no difficulty was encountered in its construction. A third pier, 890 ft. long, in water 14 ft. deep, was built with 10-ton molded blocks of 1:6 concrete lowered by an overhead gantry on a concrete bed made by divers. Mr. J. C. Inglis was the engineer, and Messrs. Hill & Lester, of London and Plymouth, were the contractors. The details of the work were described in a recent issue of "Engineering," London.

The Decomposition of Cement in sea water is the subject of a valuable monograph by Henry Le Chatelier, in the "Annales des Ponts et Chaussèes." His investigations led him to the conclusion that all hydraulic cements are decomposed by sea water, but at very unequal rates. This decomposition is slower as the content of alumina is lower and as the hydraulic index is higher. Quick-setting cements with high sulphate of lime and a high hydraulic index give very satisfactory results. The addition of pozzolana produces a considerable increase in the resistance. A dense mortar seems to be most essential to ensure the preservation of concrete in sea water. On this account, independently of all chemical action, the addition of pozzolana is important as increasing the density of the mortar.

Book Notes.

About five years ago an investigation of allowable pressures on foundations was made by Dr. E. L. Corthell in connection with harbor works in South America. He sent a circular letter to about 300 engineers in different countries, asking them to send him notes of actual pressures and attending settlements, if any, that had come under their observation. About one-tenth of those to whom these letters were sent replied, and from them voluminous tables giving facts regarding 178 works were compiled. This material was worked up as a paper for the Institution of Civil Engineers, which printed a very brief abstract of it about a year ago. The information in the paper would thus be practically lost for useful purposes, since but very few engineers have access to the unpublished manuscripts in the records of the Institution, had not Dr. Corthell arranged for the publication of the paper in full for general sale. In this way a quantity of valuable information relating to the pressures actually imposed on deep foundations is now available, and will unquestionably prove of much value to those engaged in foundation work of any sort. The paper is entitled "Allowable Pressures on Deep Foundations," and is sold in this country at $1.25 with the imprint of John Wiley & Sons, New York.

A few weeks ago attention was called in this journal to some studies made by Dr. A. S. Cushman, assistant director, Office of Public Roads, throwing much light on the nature of the corrosion of iron. A great deal of comment has been made on this announcement, and naturally enough some of these criticisms have been unwarranted on account of their proceeding from incomplete knowledge of just what Dr. Cushman has personally claimed regarding his studies. It is accordingly gratifying to state that the Office of Public Roads has issued for free distribution a monograph on the subject, written by Dr. Cushman, and containing all the information it is considered advisable to give out concerning his work at present, together with a resume of work done by others along the same line. It will be seen that the author draws attention to the investigations of Dr. Whitney, Dr. Walker and others, and it is probable that had the similar theory advanced by Mr. Freeland Howe, Jr., in a trade publication some time ago been available in scientific journals it would have similarly been noticed, although it does not appear to have been founded on experimental evidence. Dr. Cushman does not claim that no other man has ever understood the fundamental reactions upon which the rusting of iron depends, but merely states that he had to work the subject out for himself, for the available literature was unsatisfactory. The investigation was started in connection with investigations of the corrosion of fence wire requested by farmers in letters to the Agricultural Department and opens up an important possibility of using sheet iron for culverts on some classes of roads. The pamphlet explains the carbonic acid and the peroxide theories of the corrosion of iron and the reasons for considering them unsatisfactory and then outlines the electrolytic theory. Methods of stimulating and inhibiting the corrosion of iron are then explained, and the action of hydrogen peroxide on iron is discussed at some length. There is an interesting account of experimental work demonstrating electrolytic action, and the pamphlet closes with an account of some practial work done in applying the theory to prevent rusting. On account of the great interest shown in the subject, the pamphlet must be regarded as one of the most important issued by the department of Agriculture for some time.

Letters to the Editor.

A System of Structurally Reinforced Concrete.

Sir: In view of the regrettable accidents to reinforced concrete buildings at Rochester, Philadelphia and other places, it is a pertinent question whether it is not possible to make the designs of such a character that they may be "foolproof;" so that if foreign substances are accidentally introduced, or a batch of bad concrete escapes the inspector's notice, or an ignorant workman knocks out some props while the foreman's back is turned, the structure will not suddenly collapse. Such a design the writer here shows and he has been assured by several eminent engineers that it possesses features of merit.

As will be seen by the accompanying drawing, a structural steel column is utilized and for the bottom reinforcing metal of the girders and beams a pair of angles are used. These are connected to the column by means of diagonal shear bars and at intervals along the angles other shear bars, with their ends curved over to give adhesion to the concrete, are spaced as needed for the requirements of shear. These shear bars are securely connected to the angle by means of bolts and, being inclined, the shear or diagonal tension is transmitted by them directly to the bottom reinforcing angles. The beam acts like a Warren truss, the steel shear bars resisting the diagonal tension and the concrete the diagonal compression. To transmit the horizontal component of this latter to the reinforcing angles, rounds are introduced through the angles of the girders, and these together with the bolt heads and nuts and the adhesion of the concrete to the steel will amply provide for the development of all the tensile stresses in the bottom reinforcing angles.

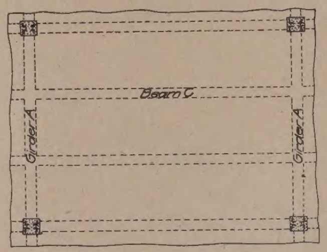
Where the beam intersects the girder a pair of light angles are placed near the top of the concrete to provide for the negative moment and prevent cracking over the girder. Several of the shear bars adjoining the girder are connected to these top angles for the purpose of developing their strength. While in the present design the girders are figured as if they were non-continuous, it might be permissible to figure them as being continuous.

A comparison of costs of this system of construction and for the standard steel cage system reveals a saving of about 10 cents per square foot of floor or about 37 per cent. for this typical floor panel. Some of the advantages of this system of reinforced concrete construction are as follows:

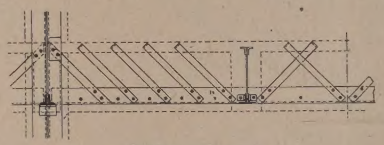
By providing a structural steel column and making a connection thereto by seating the bottom reinforcing angle on a shelf and running a diagonal bar from the angle up to the column and securely fastening the other bars to the angle, it is possible to thoroughly reinforce the beam for diagonal tension or shear, and it gives enough strength to the beam even when the concrete is green or of a poor mixture or weakened by the presence of foreign matter to guard against sudden collapse. If the forms are removed after only a few hours, the result would probably be either the concrete would crumble and drop to the next floor in small fragments not large enough to make their impact injurious or else the concrete would hold together and although perhaps it would sag perceptibly, it could not give way in a sudden manner. The angles securely tied to the column would by virtue of their tensile strength keep the structure from a sudden collapse and if the concrete had any compressive strength at all the shear bars would be brought into action, fulfilling the function of providing for the diagonal tensile stresses and by virtue of their being securely fastened to the bottom reinforcing bars, the structure would act as a whole as above stated in a manner similar to a Warren truss.

By bolting on the shear bars they may be spaced as required, the spacing being ascertained in a manner similar to that of finding the pitch of rivets in the flange of a plate girder; that is, the shear at any point is divided by the value of one bar and the quotient represents the number of bars that should be in a length equal to the effective depth of the beam. This is a distinct advantage over the method of having the shear bars a uniform length, size and spacing, or of having rods bent up at the ends of the beam only and making no provision for the intermediate shear.

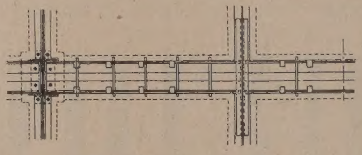
In buildings of four stories or more in height it is usually necessary in order to keep the size of interior columns down to moderate dimensions to use a core of structural steel up to within one or two stories of the roof, and in Philadelphia when this is done the building laws require this core to be designed to carry the whole load. Hence, for a building of this height or more the cost of columns would be little more for the system here described than for a rod system. As for the cost of the beam and girder reinforcing, the angles would be shipped punched in one leg only and the shear bars bent at one end and punched in the other, so that the cost of the fabricated material should be quite low, say about 2.7 cents per pound in the east f. o. b. cars and for large jobs a portable punch might be used and the cost materially reduced below the above mentioned figure, perhaps to 2¼ cents per pound. It would seem therefore that the cost of the reinforcing material might be considerably lower than the most of the patented assembled rod systems now in the market.



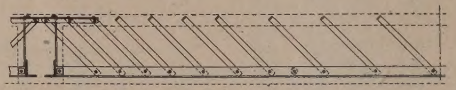
Typical Floor Panel–Plan



One Half of Girder A



Plan of One Half of Girder A



One Half of Beam C

Structurally Reinforced Concrete.

By using angles and shear bars as shown there is no danger of the reinforcement being displaced by depositing of the concrete, and an inspector could tell at a glance if all the material required was in place.

By using this system, concrete construction could be safely applied to buildings of twenty stories or more in height, for the connection between the concrete beams and girders and the structural columns, being rigid, could be designed to provide for wind pressure or earthquake. It also would be well adapted for use in subway work where it is necessary to use steel columns to keep their dimensions down to a minimum.

The writer feeling that there is a wide field for the above described invention and believing that reinforced concrete construction must eventually come to some such system has protected the salient features of the above by letters patent.

Winfield W. Conard.

Norristown, Pa.

A Proposed Municipal Engineering Board.

Sir: Will you assist one of your readers by advice or comment to form an opinion in the following matter:

A certain city has a number of engineers at the heads of its different departments. For instance, there is a city engineer, who has charge of paving, etc.; a hydraulic engineer, who has charge of the water department; an electrical engineer, who has charge of electric subways, conduits, etc.; a harbor engineer, who has charge of the work around the water front; and a park engineer, who has charge of the engineering work in the park department; also a superintendent of street cleaning. These men are selected, in theory, at least, for the special ability each is supposed to have for his particular work.

It is proposed to form a board of engineers of the above departmental heads, and that this board of municipal engineers, as a whole, form a board of consulting engineers for the members of the city government. In the case of criticism of the plans of any one of these engineers, this board will pass an opinion on such plans, and thus determine for the lay members of the city government the justice of the criticism mentioned. If approved by the mayor, this board may correct or change the plans of the departmental heads to meet the ideas of the mayor and this board as a whole. It is stated that, under this idea, the city may be saved the fees of experts that might otherwise be called in.

Let us assume that within the sphere of his duties, each departmental head is an expert. Waiving the question as to whether the advice of an electrical engineer would be valuable on a question of piling, or whether the opinion of the street cleaning commissioner be worth anything on questions concerning the details of water supply, the question arises in the mind of your inquirer as to whether or not these engineers, joining in such a board and responding to requests for advice on subjects in which they may be inexpert, are doing themselves and their profession justice.

We hear a great deal of complaint, from time to time, regarding the small salaries paid members of the engineering profession. Your paper has several times suggested that the blame for this might frequently be laid at the doors of the individual members of the profession, and that a proper appreciation of his duties, responsibilities and ethics would do much toward placing the engineer and the profession in such a light before the general public as would result in the latter willingly paying a competent engineer a proper compensation for his work.

Should an engineer, no matter how thoroughly familiar with one specialty, allow himself to be placed in a position of advising or criticising the specialty of another and in which he is not thoroughly posted? Will your other readers interested, out of the breadth of their experience, help to clear up the mind of your inquirer by a frank statement of opinion?

Very truly yours, Specialist.

[This plan is about the worst example of executive confusion The Engineering Record has heard suggested. It is discussed in the editorial pages of this issue.]